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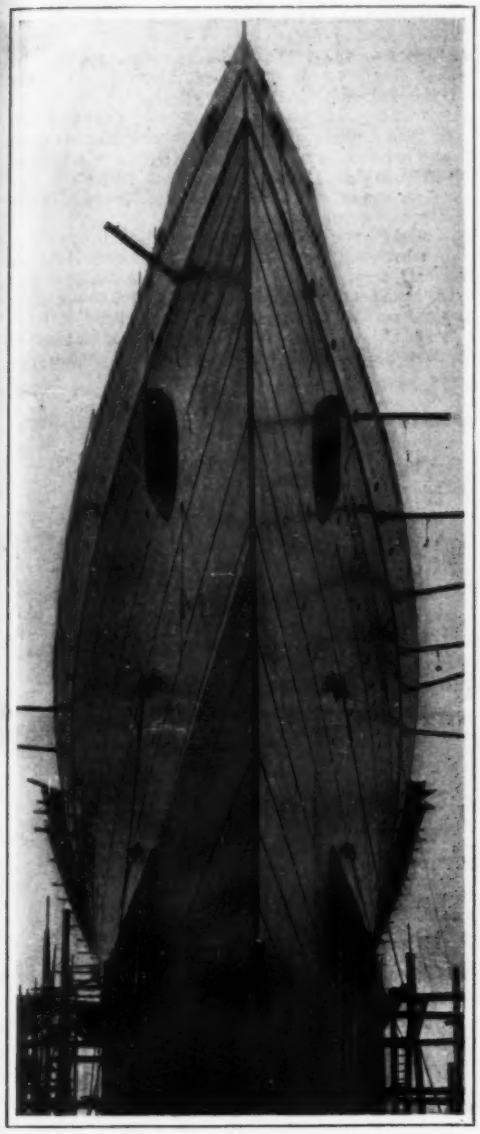
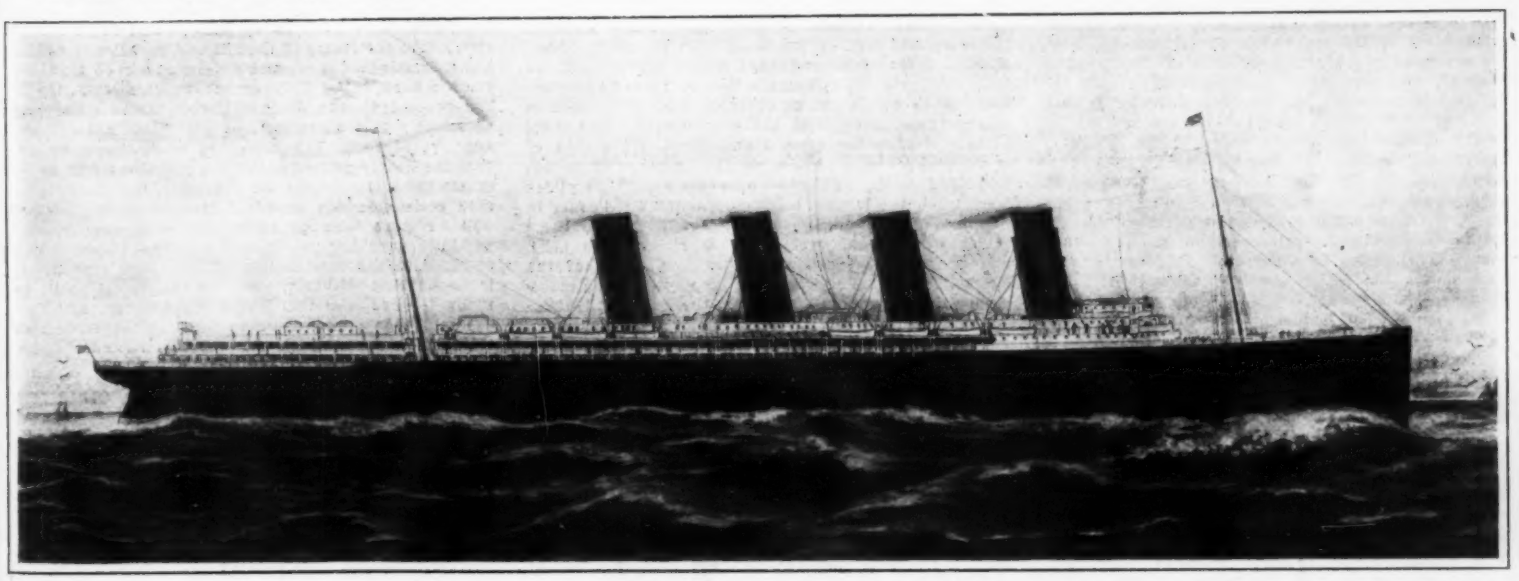


REMARKABLE BOW VIEW OF THE "LUSITANIA," SHOWING THE FINE LINES OF THE HULL.

STERN OF THE "LUSITANIA," SHOWING ONE OF THE HUGE PROPELLERS.



THE VESSEL MEASURES 785 FEET OVER ALL AND 88 FEET BEAM. TURBINE ENGINES ARE USED DEVELOPING 68,000 I. H. P.

THE CUNARD LINER "LUSITANIA."

THE CUNARD LINER "LUSITANIA."

ON June 7 the latest of the modern transatlantic fliers slipped from her ways into the waters of the Clyde—the Cunarder "Lusitania." The great turbine liner was constructed in the works of Messrs. John Brown & Co., Clydebank, and, together with her sister ship the "Mauritania," to be launched later in the year on the Tyne, constitutes the latest word in marine engineering. When the builders of the "Great Eastern" undertook the designing of that huge craft, it was their intention to construct not only the largest vessel that had ever been built, but at the same time the largest that could be built. How badly they underestimated the possibilities of their profession is readily shown by a comparison of the dimensions of the "Great Eastern" and the "Lusitania"; the respective horse-power of the engines alone is sufficiently startling—8,000 as compared with 68,000. And now it appears that the Hamburg-American Line, not to be outdone by its British rival, has ordered a still greater marine leviathan, which is to be afloat by 1908, and which undoubtedly will be the most remarkable vessel of its kind ever launched.

The "Lusitania" has been designed for a speed of 25 knots an hour, a speed which is a knot and a half in excess of that of the fastest of the existing ocean greyhounds, the "Kaiser Wilhelm II." of the North German Lloyd. To propel the great hull through the water at this speed, the "Lusitania" is provided with turbine engines developing 68,000 indicated horse-power, and driving four screws. It was estimated that the power requisite to attain this high rate of speed would be between 66,000 and 68,000 horse-power, and the use of four propellers was determined upon, in order more effectively to distribute this enormous power. The question of the desirability of the turbine motor was decided by an investigating committee, who voted unanimously in favor of it. The form of hull most suitable for the contract conditions was ascertained by exhaustive tests with models in the experimental tank of the British Admiralty, and in a similar one especially constructed at the Brown shipbuilding works.

The form of the stern and the propeller distribution offered novel difficulties which, it is believed, have been successfully overcome by careful design after systematic experimenting. Notwithstanding that the wing propellers are set well forward of the inner pair, the blades of the former do not project beyond the fore-and-aft beam line of the vessel. This is largely due to the great beam, 88 feet, and the very fine run. The vessel is 785 feet long over all, and 760 feet between perpendiculars. The extreme width is a significant advance in the design, and has resulted in a very handsome model. The departure from accepted structural principles is shown in the fact that the length of the "Lusitania" is only 8.63 times the beam, whereas in vessels constructed a decade ago the factor is well over 9. The molded depth, further, is considerably greater than that in earlier ships, and in addition there is an added deck, making eight of these in all. The propeller shafts are inclosed within the framing, which is bossed out for the purpose, and the hull aft is cut away, forming an arch and allowing the propellers to work in free water without overlapping of the blades. The great beam gives the vessel exceptionally stable qualities, and the construction throughout is such that the "Lusitania" will probably be not only the fastest ship of her class, but the most strongly built as well.

The steam-generating plant includes twenty-five boilers having a total of 192 furnaces. The boilers are arranged in four separate compartments, each of which has a large oval funnel, 24 feet across the larger diameter and 155 feet in height from the keel. The total grate area of the furnaces is nearly 4,000 square feet; the heating surface of the boilers approximates 160,000 square feet, giving 40 square feet of heating surface per unit of grate area.

The turbines which drive the vessel are of enormous size; they are the largest so far constructed for similar work. The low-pressure engines alone weigh nearly 430 tons. The diameter of the rotor of the latter is 15 feet 8 inches, the blades attaining a maximum length of 22 inches toward the low-pressure end, giving a maximum diameter of the rotor of 19 feet 4 inches. The peripheral speed of the rotor under normal conditions of working will attain a maximum of 142 feet per second. The engines have been designed with the greatest care, and in them have been incorporated the latest advances in turbine construction. Especially is this true of the casings, which have been carefully proportioned to resist circumferential stress without undue weight. By the use of the turbine, and by great increase in displacement, it has been possible to add enormously to the engine power in order to obtain the increase in speed, though this is comparatively slight in itself. Experience has given some interesting figures bearing upon this question. Thus twenty years ago the ratio of power to displacement for a 20-knot speed was 1.35 to 1; for 22 knots ten years ago, 1.66 to 1; and to-day for 25 knots, it is 1.8 to 1. Consequently, for an advance in speed in twenty years equal to 25 per cent, the power has increased from 14,000 to 68,000, or nearly 400 per cent. It is true that with the improved economy the coal consumption per unit of power is considerably less—25 per cent; but notwithstanding the shorter time taken on the voyage from Liverpool to New York, owing to increased speed, the total tonnage of coal has gone up from 1,900 to 5,000 tons, a consumption of nearly 1,000 tons a day.

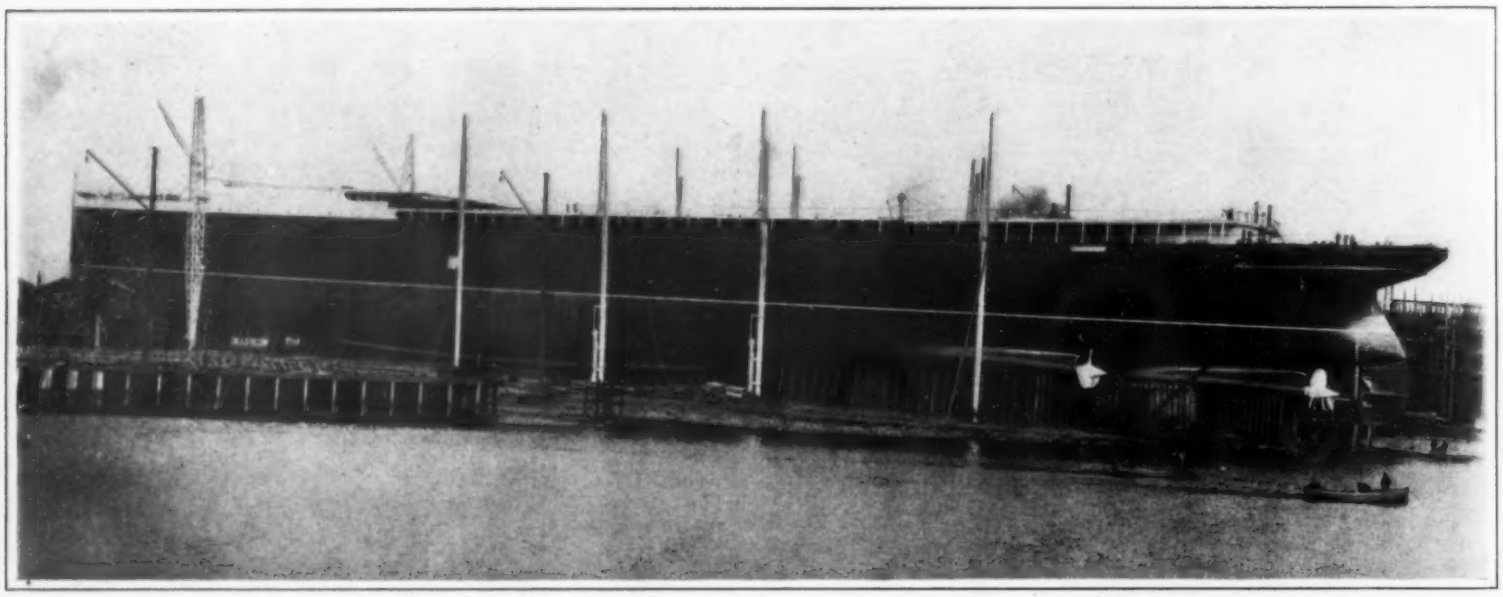
The keel plate of the vessel is 5 feet in width and 3¾ inches in thickness, and is flush with the outer bottom of the ship. Associated with this flat keel is a vertical keel 5 feet high by 1 inch thick, to which are attached the main frames of the hull. The double bottom is divided into compartments for the stowage of the water ballast. The water-tight compartment system is carried out wherever possible, and the lower deck is made completely water-tight, below it being the orlop and lower orlop decks with the main, upper, shelter, promenade, and boat decks above—eight in all. Compartment communication by means of water-tight doors which can be operated from the bridge is incorporated throughout the construction. The steel plates covering the frames and forming the skin of the hull have a thickness of 1½ inches, and in all, including decks, bulkheads, and casings, 26,000 plates were used, the largest being approximately 40 feet in length and weighing about 5 tons. To secure these plates in position, over 4,000,000 rivets were used, aggregating 500 tons in weight. Some idea of the extent of the ribs and framing employed in the structural work may be gathered from the fact that if these were placed end to end, they would reach for a distance of 30 miles.

As the vessel is being subsidized by the British Navy Department, it is built in accordance with certain requirements of the Admiralty, among which were the specifications that there be two sets of steering gear, one placed below the water line, and that the bunker arrangement be such as to protect the motive equipment when the vessel is used as an armed cruiser. The offensive armament in time of war will comprise twelve 6-inch guns.

The ground gear is the strongest that has yet been built for marine purposes, and will be ample to hold the 45,000-ton vessel, even in such swift-flowing tidal streams as the Mersey. The three anchors each weigh 10 tons, and are provided with 1,800 feet of cable which, in its turn, is the largest that has so far been made. The chains are hand-forged and are composed of 22-inch links, the iron of which is 3¾ inches in diameter, while the weight of each link exceeds 160 pounds.

The passenger accommodation has been carried out upon a lavish scale, and owing to the immense size of the vessel it has been possible to give a clear height of 10 feet 6 inches between decks, so that the apartments are spacious in proportion. The ship can carry 550 first-class, 500 second-class, and over 1,200 third-class passengers, bringing the total floating population, with a full complement of passengers and 860 officers and crew, up to 3,200 souls. Approximately one-half of the crew will be required for the machinery department of the vessel. Two large electric elevators are provided for the convenience of passengers, while there are six similar lifts for the handling of mails, freight, and for other purposes. Twelve hundred side-lights and windows, including 500 cabin ventilating lights, provide natural illumination on a liberal scale. Artificial illumination will be provided by 5,000 incandescent lights, requiring a total length of wiring of 200 miles, with main cables 1½ inch thick. The various staterooms and saloons will be equipped with telephonic communication with the chief steward, and similar facilities will be provided throughout the navigation, engineering, and administrative departments of the vessel. The lookout men will also be in communication by telephone with the navigating bridge, which is placed 110 feet above the keel. The vessel will be provided with Marconi wireless telegraphic apparatus.

The vessel's great speed will enable her to cover the distance between New York and Queenstown in four and a half days, and it is estimated that the expenses of the round trip will approximate $100,000 a day. The total cost of the vessel, when completed, will be nearly $2,250,000, and the expense of maintenance and depreciation will aggregate some $150,000 per month.



READY FOR THE LAUNCHING. THE "LUSITANIA" ON THE WAYS, SHOWING THE PORT PROPELLERS.

THE CUNARD LINER "LUSITANIA."

The great size of the hull, weighing, ready for launching, 16,000 tons, is well illustrated by the fact that the stern frame weighs 50 tons, and the propeller brackets 30 tons. These are of cast steel, and are hydraulically riveted in place. The brackets for the wing propellers have heavy flanges, and are built directly into the frame of the ship. The balance rudder has a framing of steel, and weighs nearly 65 tons, the rudder head being 25½ inches in diameter. Up to the present time a draft of 29 feet was considered enormous; this dimension of the "Lusitania," however, is 33 feet. The designers of the ship believe that the deeper immersion of the propellers will so increase the efficiency of their operation, that the greater skin resistance due to the increased wetted surface will be more than counterbalanced. At the present writing everything points to the success of the design involved in the construction of these two vessels. It is hoped that within a year the "Lusitania" will be ready for her trial trip across the Atlantic, and that she will then demonstrate in practice the success of the theories upon which she was constructed.

THE ACTION OF SEA WATER UPON CONCRETE.

By J. WATT SANDEMAN.

IT has been known for a considerable time that chemical action takes place between the acids contained in sea-water and the lime contained in Portland cement; and that if Portland cement concrete be made porous or permeable, so as to enable sea water to act continuously throughout its mass, the cement will gradually become disintegrated, and ultimately be destroyed by such action.

This has happened, and is still happening, to a number of dock and pier works both in this country and abroad; and that such destruction has been due to the porosity of the concrete and the action of sea water

upon it has been proved by investigation of concretes in dock works that have failed.

While the author has had experience of this destructive action of sea water, he has also had abundant proof of the permanent stability of dock and pier works which he has constructed in impervious concrete.

PROPOSED STANDARD PROPORTIONS FOR CONCRETES.

With the view to arrive at standard proportions for concretes which would enable them to permanently resist the action of sea water, the author has carefully studied the question, and the following record of the results at which he has arrived is based on actual tests and long experience in the construction of dock and pier works in concrete; and although the proportions recommended, and the system of measuring sand and aggregates separately differ from ordinary practice, yet the author contends that for sea works, and particularly for graving docks, should proportions be used other than those proposed in Tables I. and II., there would be risk of percolation by sea water, which would certainly be followed by disintegration of the concrete.

TO MAKE IMPERVIOUS CONCRETE.

Permeability in concrete is due either to the porosity or the insufficiency of the mortar, or to faulty manipulation of the materials. For impervious mortar the maximum proportion of sand must not exceed two parts to one of cement. For impervious concretes the volume of the mortar must be in excess of that of the maximum voids in the aggregates, so as to fill these and surround the aggregate. To effect this the most extreme conditions which can occur in practice must be allowed for, viz., maximum reduction in volume of cement and sand when made into mortar; maximum voids in the aggregate; and unavoidable irregularities in manipulation of concrete.

For impervious concretes in which displacers are used it is necessary that the size of gravel be limited to what would be gaged by a sieve with meshes 1½ inch square, and broken stone to what would be gaged by meshes ¾ inch square. When gravel is above that size it separates from the mortar, accumulates together while being deposited, and causes voids in the concrete.

The proportions of materials in Tables I. and II. are such as will fulfill the foregoing conditions, and (with proper manipulation) produce concretes which will perfectly resist the action of sea water.

VOIDS IN MATERIALS AND REDUCTION IN VOLUME.

The author ascertained that the voids in gravel vary from 34 to 40 per cent of the volume of the gravel, and the voids in broken stone from 34 to 54 per cent. The reduction in volume of cement and sand when mixed and made into mortar varies with different ratios of cement to sand, with different ratios of voids in the sand, and with the amount of moisture in the sand; damp sand (such as is often used for concrete) bulking much more largely than dry sand.

The author found that the reduction in volume of cement and ordinary dry sea sand by being made into mortar varied from 12 per cent for 1 to 4 mortar to 22 per cent for 1 to 1 mortar, and that the reduction in volume for 1 to 1 mortar when the sand was damp increased to about 30 per cent.

Taking the maximum reduction in volume of cement and sand when made into mortar at 30 per cent, the only other reduction between the volume of the dry materials used and of the concrete produced is that due to the amount of mortar which goes to fill the voids in the gravel or stone. These voids should be taken at the maximum, viz., 40 per cent for gravel, and 54 per cent for broken stone.

These reductions combined make a total reduction between the volume of the dry materials, and that of the concrete, varying from 35 per cent for concrete in the proportion of 1 cement, 2 sand, 3 gravel, to 44 per cent for concrete in the proportion of 1 cement, 4 sand, 7 broken stone.

DISPLACERS.

The proportion of ordinary-sized rubble displacers which can be satisfactorily deposited by hand in concrete was ascertained by the author not to exceed one-fourth of the volume of the set concrete.

MODE OF ASCERTAINING WEIGHTS OF MATERIALS AND RELATIVE COSTS OF CONCRETES.

Taking, as an example, impervious concrete in the proportion of 1 cement, 2 sand, and 3 gravel with displacers, the weights of the materials and the cost of a cubic yard of concrete will be ascertained as follows: 1 cement, 2 sand = 3 vols. allow 30 per cent, or 0.9 vol., for reduction by being made into mortar. Gravel 3 vols., allow 40 per cent, or 1.2 vols., for voids occupied by mortar. Total, 6 vols., reduced by 2.1 vols. = 35 per cent reduction, or the ratio of dry materials = 1.538 to 1 of concrete. 1.538 cubic yards = 41.5 cubic feet, which, divided in the ratio of the materials, viz., 1—2—3, will give:

	Assumed Rates per Ton.	s.	d.
6.9 cubic feet cement × 85½ lb. = 5.26 cwt.	at 28s.	7	4
13.8 cubic feet sand × 85 lb. = 10.5 cwt.	at 3s.	1	7
20.8 cubic feet gravel × 112 lb. = 20.8 cwt.	at 3s.	3	1
41.5		12	0
Average cost of mixing and conveying materials, including use of plant (say)		3	0
Timber boarding and water		1	3
		16	3
Contractors' profit (say) 15 per cent.		2	5
Cost of 1 cubic yard of concrete without displacers		18	8
Deduct one-fourth for displacers		4	8
		14	0
Add ¼ cubic yard = 6¾ cubic feet of stone as displacers × 140 lb. per cubic foot = 8.44 cwt. at 4s. per ton.		1	8
Cost of 1 cubic yard of concrete with displacers		15	8

The foregoing estimated cost would be about 5 per cent above the average cost of concrete estimated in the same way, on account of maximum reduction of cement and sand, and maximum voids having been taken.

The tables herewith show proposed standard proportions for concretes for sea works, and concretes for general purposes, and their relative costs estimated in the foregoing manner; also the volumes of mortar produced from cement and sand, and the ratios of mortar to gravel or broken stone.

It will be seen that more mortar is allowed for concrete in which broken stone is used, as it does not yield to treading or ramming like concrete made with gravel, and does not allow displacers to sink readily into it. Concrete made with broken stone, although it can be made impervious when displacers are used, is therefore not so well adapted to receive them.

Concretes Nos. 7 to 10 and Nos. 12 and 13 have a ratio of mortar which would not allow of displacers being used, and for these the gravel may vary in size up to what would be gaged by meshes 2½ inches square, and broken stone up to what would be gaged by meshes 1½ inch square.

The tables show the reduction in cost, without diminution in strength of concrete, which is obtained by the use of displacers; No. 6 concrete of 1 cement, 2 sand, 3 gravel, with displacers, costing 19 per cent less than the same concrete without displacers.

The cost of No. 6 is also the same as that of the much weaker concrete No. 12, consisting of 1 cement, 4 sand, and 7 broken stone without displacers.—Engineering.

PROPOSED STANDARD PROPORTIONS FOR CONCRETES.

TABLE I.—IMPERVIOUS CONCRETES FOR SPECIAL PARTS OF WORKS, SUCH AS AROUND GREENHEART DOCK SILLS AND GATE QUOINS. No. 2 CONCRETE IS ALSO ADAPTED FOR PIER WORKS NEAR LOW-WATER LEVEL WHERE EXPOSED TO WASH OF WAVES OR STRONG CURRENTS.

Concrete without Displacers.

Volumes.				Value of Mortar Produced from Cement and Sand.	Ratio of Mortar to Gravel or Broken Stone.	Unit Costs of Concretes per Cubic Yard, taking No. 6 Concrete as the Standard of Comparison.
Number of Concrete.	Cement.	Sand.	Gauged by Meshes ¾ In. Square.			
1	1	1½	1½ broken stone	1.75	per cent. 100	141
2	1	1½	2 gravel	1.75	87.5	134

TABLE II.—IMPERVIOUS CONCRETES FOR MARINE WORK, SUCH AS SEA PIERS AND DRY DOCKS, ALSO RESERVOIR WALLS, &C.

Concrete without Displacers.

Volumes.				Volume of Mortar Produced from Cement and Sand.	Ratio of Mortar to Gravel or Broken Stone.	Unit Costs of Concretes per Cubic Yard.
Number of Concrete.	Cement.	Sand	Gravel Gauged by Meshes 1½ In. Square and Broken Stone by Meshes 1 In. Square.			
3	1	2	3 gravel	2.1	per cent. 70	119
4	1	2	3½ "	2.1	60	117
5	1	2	3 broken stone	2.1	70	115

Concrete with Displacers.

—	—	—	Gauged by Meshes 1½ In. Square.	Displacers.	—	Ratio of Mortar to Gravel and Displacers.	—
6	1	2	3 gravel	¼ cubic yard	2.1	per cent. 48.8	100

NOTE.—For concrete deposited *in situ* under water, also near low-water level, where exposed to wash from waves or tidal currents, no displacers should be used.

TABLE III.—ORDINARY CONCRETES (NOT IMPERVIOUS) FOR FOUNDATIONS, RETAINING-WALLS, &C.

Concrete without Displacers.

Volumes.				Volume of Mortar Produced from Cement and Sand.	Ratio of Mortar to Gravel or Broken Stone.	Unit Costs of Concretes per Cubic Yard.
Number of Concrete.	Cement.	Sand.	Gravel Gauged by Meshes 2½ In. Square, and Broken Stone by Meshes 1½ In. Square.			
7	1	2	4 gravel	2.1	per cent. 52.5	114
8	1	2½	5 "	2.45	49	107
9	1	3	5 broken stone	2.8	56	108
10	1	3	6 gravel	2.8	46.6	102

Concrete with Displacers.

—	—	—	Gauged by Meshes 1½ In. Square.	Displacers.	—	Ratio of Mortar to Gravel and Displacers.	—
11	1	3	4 gravel	¼ cubic yard.	2.8	per cent. 48.8	107

TABLE IV.—CHEAPER CONCRETES FOR WORKS IN WHICH NO GREAT STRENGTH IS REQUIRED.

Concrete without Displacers.

Volumes.				Volume of Mortar Produced from Cement and Sand.	Ratio of Mortar to Gravel or Broken Stone.	Unit Costs of Concretes per Cubic Yard.
Number of Concrete.	Cement.	Sand.	Gravel Gauged by Meshes 2½ In. Square, and Broken Stone by Meshes 1½ In. Square.			
12	1	4	7 broken stone	3.5	per cent. 50	100
13	1	4	8 gravel	3.5	43.7	97

Concrete with Displacers.

—	—	—	Gauged by Meshes 1½ In. Square.	Displacers.	—	Ratio of Mortar to Gravel and Displacers.	—
14	1	4	5 gravel	¼ cubic yard	3.5	per cent. 43.8	88

Telluric Currents.—M. Guarini recently presented to the Société Belge d'Astronomie his theory relative to telluric currents, which has occasioned much interest in scientific circles. The causes of currents passing through the earth are generally external. He holds that none of the former theories enunciated for their explanation, assigning the influence of the wind, of the aurora borealis, of rain, storms, electro-chemical effects, pays attention to the incontestable fact that there is a telluric current, of well-determined direction, proceeding from northwest to southeast. Now, a constant effect cannot be due to causes so variable and intermittent. These atmospheric perturbations produce, some by friction (the wind), others by induction (hail, rain, clouds), variations of potential at certain points. Fluctuations of potential occasion at times sudden variations in the intensity, and even in the direction of telluric currents. The telluric current of constant direction cannot be due to a cosmic effect; that is, to the rotation of the earth around the sun. By the rotation of the earth a current would be induced in the atmosphere of opposite direction to that of the rotation (as in dynamos). The variable current induced in the atmosphere would in its turn induce in the terrestrial crust a current of opposite direction; that is, of the same direction as the rotation of the earth. The sun induces a positive charge in bodies exposed to it. On the other hand, it follows from demonstrations, particularly of Palmieri, that the current of the earth is a current induced by the atmosphere. As the earth revolves from west to east, it has the same direction as the constant telluric currents. It is possible, as Ampère maintained, that it is the telluric current that produces the deviation of the magnetic needle. In addition to other advantages of telluric currents, they are useful in agriculture, since they decompose chemical products met with in the soil, and form others more assimilable by plants. M. Jacobs, the president of the society, while warmly felicitating the author on the originality and practical importance of his views expressed the opinion that they would aid in elucidating numerous electrical phenomena in the physics of the globe.

INTERNAL-COMBUSTION MOTORS.*

By DUGALD CLERK, M. Inst. C.E.

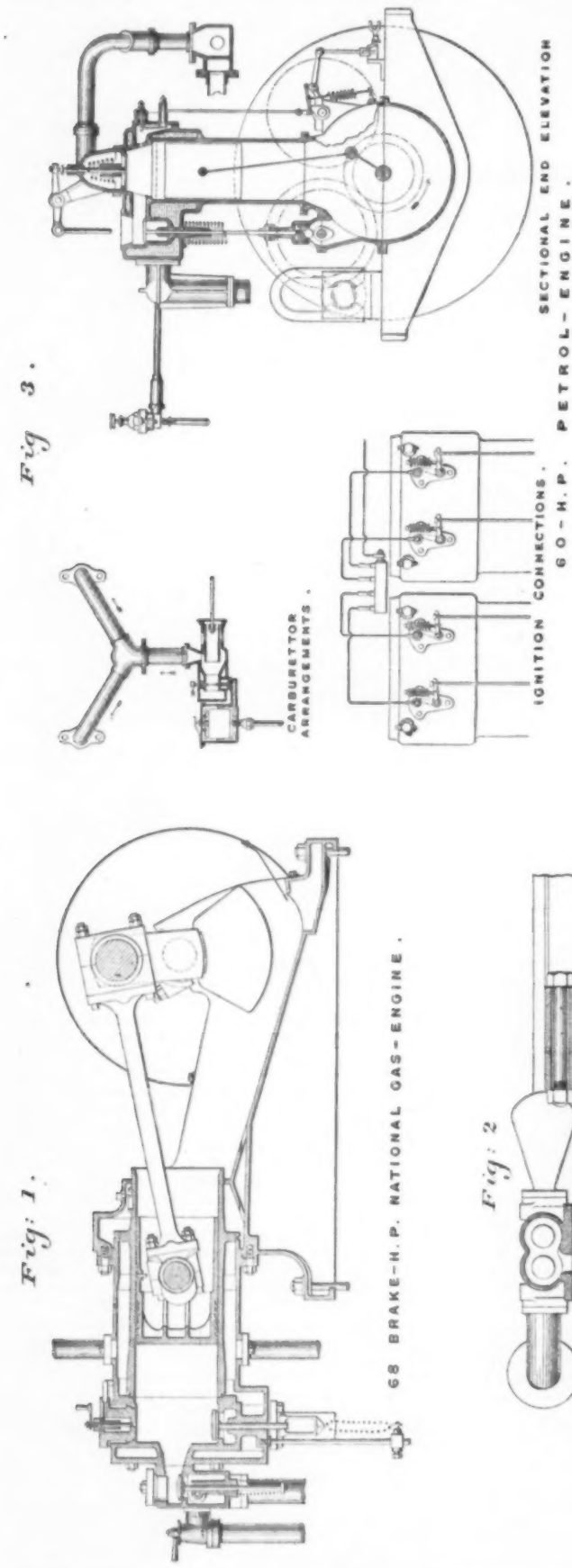
DURING the past twenty-five years engineers have applied internal-combustion motors to all manner of uses, in powers ranging between the tiny ½-horse-power motor and the huge 2,000 horse-power engine. They have adapted the motors to the consumption of many different kinds of inflammable gases and vapors, and they have continually increased both mechanical and thermal efficiency, until, at the present time, these motors compete with steam in almost every field. For small and moderate powers their advantages greatly outweigh those of steam; and, accordingly, we find that here they have displaced steam and revolutionized the application of power in towns for the industries requiring only moderate forces. At first these motors were practically limited to the use of town gas; and, although the heat efficiency was much superior to that of steam, yet the gas-fuel was more expensive per heat-unit than the cheaper coals which could be used under steam boilers. This led to the application of producer-gas by Mr. Dowson, which extended the gas-engine field by reducing the cost per heat-unit to less than half that of coal-gas. Later, the heavy hydro-carbons were pressed into the service, in the form of paraffin and petroleum oils, and this widened the field to include agricultural motors and motors required in positions where no town's gas or producer-gas was available. In this field engineers are indebted principally to the labors of Messrs. Priestman and Messrs. Hornsby.

Light hydro-carbons had been early utilized in these motors; but it required the advent of the motor-car, with the beautiful small high-speed engines originated by Daimler, to make petrol consumption a matter of commercial importance. The production of these petrol-engines is now conducted in all countries on a very large scale indeed; and the desire to utilize local inflammable material has led to the use of alcohol in similar small motors specially arranged for that fuel.

The demonstration by Mr. B. H. Thwaite in 1895 that the so-called waste-gases from blast-furnaces could be used in gas-engines has led to the introduction of the very large gas-motors now becoming common both on the Continent and in this country.

Other gases are utilized for these motors: in America natural gas and wood-gas; and in Britain and on the Continent water-gas and coke-oven gas. In making these numerous applications the engineer has met all manner of difficulties—mechanical, physical, and chemical; and, with the assistance of such scientific knowledge as existed, he has overcome many, and skillfully evaded others.

Much has been done, but more still remains to be done before finality can be said to be even approximately attained.



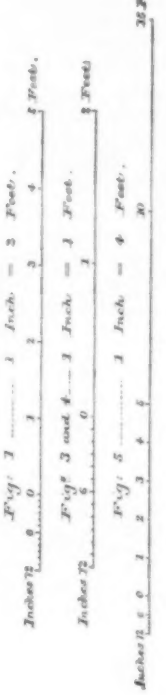

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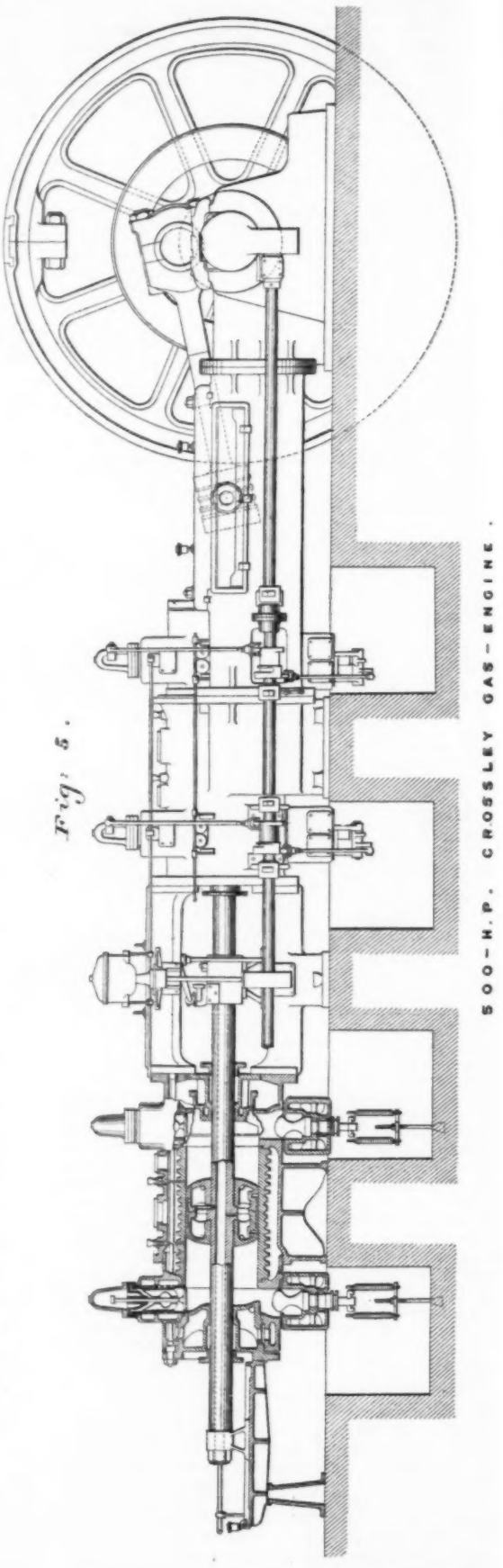
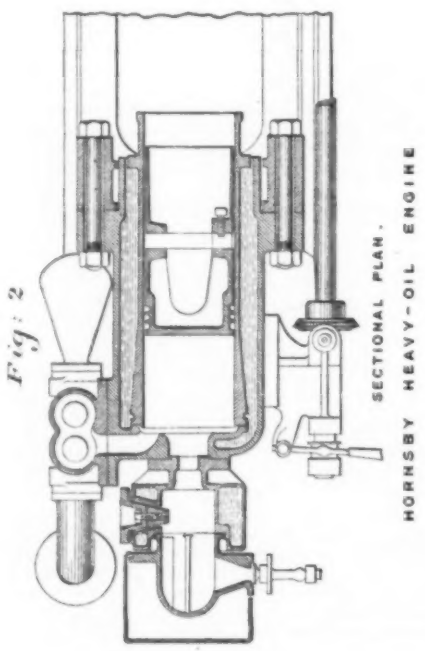
Fig. 1 ..... 1 Inch. = 3 Feet.
Inches 12 0 1 2 3 4 5 Feet.
Fig. 3 and 4 ..... 1 Inch. = 1 Foot.
Inches 12 0 1 2 3 Feet.
Fig. 5 ..... 1 Inch. = 4 Feet.
Inches 12 0 1 2 3 4 5 20 30 Feet.





It is my privilege to-night rather to point out what remains to be done than to describe what has already been done. Nevertheless, it is desirable to say something as to what has been done, in order to appreciate from past history the probable line of future progress. In the past the work of the physicist, the chemist, the engineer-physicist, and the engineer has been fully called upon to enable the existing position to be attained. Much knowledge is now available on multifarious points in connection with the motors, and they are undoubtedly better understood to-day

* Being the "James Forrest" Lecture, delivered at the Institution of Civil Engineers, Session 1903-1904. Excerpt Minutes of Proceedings of Institution of Civil Engineers. Vol. civiii. Session 1903-1904. Part iv.

than at any previous time. Many old fallacies have disappeared, although, unfortunately, some new ones have taken their place. Much difference of opinion still exists on physical and chemical points of the highest abstract scientific interest; but all are agreed, so far as practice is concerned, on certain main features. These leading features are: initial compression of the working fluid, exposure of the flame to the smallest area of cooling-surface for the shortest time, and the use of the lowest flame-temperatures consistent with high available pressures. In many cases motors deviate somewhat from these understood requirements; generally not from ignorance on the part of the designers, but from some stern practical necessity. Some of these matters, both practical and scientific, will be here discussed.

Development has followed two main lines. First, improvements relating to the motor itself, including changes in the thermo-dynamic cycle, followed in the treatment of the working fluid and the inflammable gas within the motor by the modification of such details as admission-valves, igniting devices, governing devices and water and air-cooling devices; starting-gear has also been carefully studied, and, both from the thermo-dynamic and the mechanical point of view, it may be safely said that these motors have attained a great measure of perfection. Second, parallel with the improvements relating to the motor itself have proceeded those relating to means of generating the inflammable gaseous or vapor fuel intended to operate the motor. These improvements have related to the economical production of ordinary coal-gas; to the effective production of producer-gas from anthracite, bituminous non-caking coal, coke, and other solid fuels; to the treatment of heavy and light hydro-carbons and alcohol, to produce an effective inflammable vapor; and to the purification and collection of blast-furnace gas, coke-oven gas and natural gas.

With regard to mechanical improvements, four well-marked divisions may be considered: (1) Motors for town gas; (2) motors for heavy oil; (3) motors for light oil and alcohol; and (4) motors for producer and blast-furnace gas.

To illustrate these four divisions the following diagrams have been prepared:

Fig. 1 is an example of an engine of standard type for town gas, giving about 68 horse-power, as made by the National Gas Engine Company, Limited.

Fig. 2 is a sectional plan of a Hornsby heavy oil engine.

Fig. 3 illustrates the carbureter arrangements and ignition connections of a Daimler engine of 60 horse-power, made by the Daimler Company at Cannstadt, as used in the Mercedes car which won the Gordon-Bennett race last year.

Fig. 4 is drawings of a 22-horse-power Daimler motor, which was used in one of the successful competing cars at the Automobile Club trials of last year.

These engines—the Mercedes and Daimler—operate with petrol.

Fig. 5 shows the most recent form of Crossley engine for producer and blast-furnace gases. This is an engine of 500 horse-power.

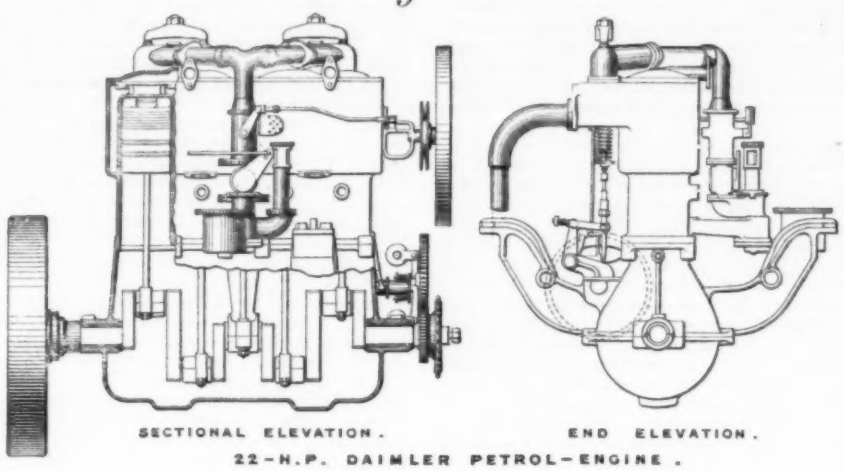
Fig. 6 illustrates the latest "National" gas engine, intended to indicate 300 horse-power in one cylinder, to be used for operation with producer or blast furnace gas.

Fig. 7 shows in section a 250-horse-power engine of the well-known "Premier" type, also for producer or blast furnace gas.

Fig. 8 shows a 600-horse-power Crossley engine of a somewhat different type.

The engines of moderate size, such as 60-horse-power engines, are built without water cooling applied either to the piston or to the exhaust valve, but in larger engines, such as the large "Crossley" and "Premier" engines, both pistons and exhaust valves are carefully water cooled.

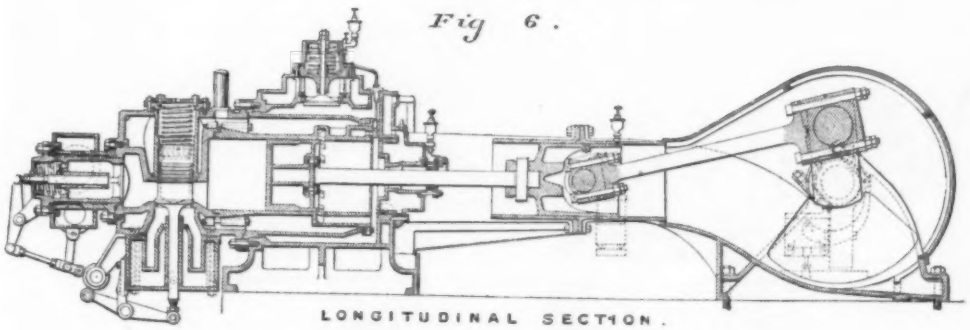
Fig 4.



SECTIONAL ELEVATION. END ELEVATION.

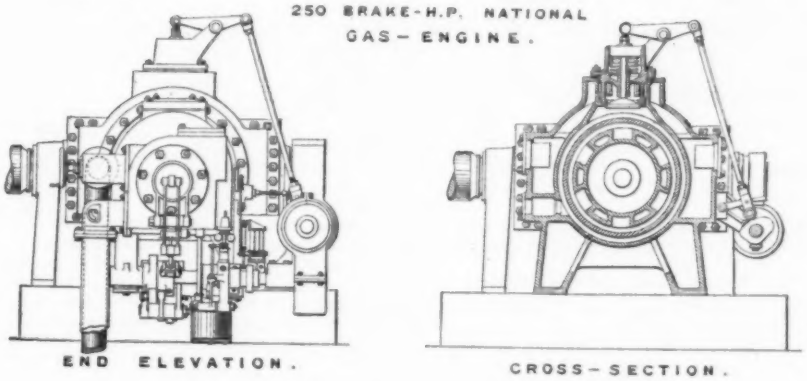
22-H.P. DAIMLER PETROL-ENGINE.

Fig 6.



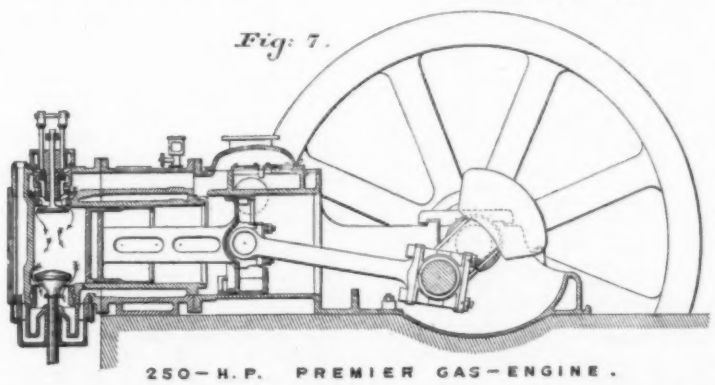
LONGITUDINAL SECTION.

250 BRAKE-H.P. NATIONAL GAS-ENGINE.



END ELEVATION. CROSS-SECTION.

Fig. 7.



250-H.P. PREMIER GAS-ENGINE.

Fig. 1. National gas-engine of 68 brake-horse-power. Diameter of cylinder, 14 inches; stroke, 22 inches; speed for ordinary work, 160 revolutions per minute; speed for electric lighting, 200 revolutions per mirute.

Output at 160 revolutions per minute, 56.5 brake horse-power; output at 200 revolutions per minute, 68.5 brake horse-power; thermal efficiency indicated, 29.5 per cent; mechanical efficiency, 85 per cent for electric lighting and 87 per cent for ordinary work. $\frac{1}{r} = \frac{1}{5}$.

This Otto-cycle gas-engine is a good example of typical English design; it has three lift-valves, viz., charge-inlet, exhaust, and gas-supply. The gas-supply valve is governed by the "hit-or-miss" method. In many of these engines electrical ignition is adopted by means of a magneto-machine and a contact-break within the cylinder. For the smaller engines tube-ignition with a timing valve is used. It is built in sizes ranging between 2 brake horse-power and 300 brake horse-power.

The indicated thermal efficiency varies between 23 per cent in the smallest engine, and 31 per cent in the larger engines.

The National Gas Engine Company, Limited, have built in England more than ten thousand of these engines.

Fig. 2. Sectional plan of the cylinder and vaporizer of a Hornsby heavy-oil engine.

In the latest form of this, the most successful of all the heavy-oil engines, the combustion chamber is divided into two parts, the inner with, and the outer without water-jacket. The combustion chamber connects with the cylinder by a reduced passage. The inlet and exhaust valves are placed outside the cylinder and communicate with it by a passage. The outer part of the combustion chamber is heated by a lamp, then oil is injected, and the engine is started by hand if small, and by compressed air if large. The heat of the combustion chamber vaporizes the oil and also ignites the vapor, and the temperature is kept up to a sufficiently high point by the heat of the successive explosions. The ignition is due partly to the wall temperature and partly to the heat of compression in the hot combustion chamber. This engine thus operates without other igniter than the hot walls. The large port and valve surface is necessary to perform the various operations of vaporizing the oil and mixing it with the air charge and igniting it during compression. The arrangements enable ignition to be automatically timed and pre-ignition to be avoided, but they involve large cooling surface and comparatively low compressions. The thermal efficiency is therefore unavoidably lower than that of a gas engine of corresponding power. This is clearly shown by a test, by Prof. Robinson, of an engine having a cylinder of 14.5 inches diameter and 17 inches stroke, running at about 200 revolutions per minute, with Russoline of specific gravity of 0.825. The compression was 60 pounds per square inch above atmosphere, the maximum pressure 168 pounds per square inch, and the mean pressure 44.4 pounds per square inch, at full load.

The indicated thermal efficiency was 21 per cent, and the mechanical efficiency 84.2 per cent. This engine is the most extensively used of all the heavy oil-engines of the world, Messrs. Hornsby having built many thousands of them in England. The success of this engine shows very clearly that it is often better to be content with a lower heat efficiency in order to obtain a practical engine, free from delicacy of construction and easily kept running under the most adverse conditions.

Fig. 3. 60-horse-power Daimler petrol engine of the Mercedes car, which won the Gordon-Bennett race in Ireland in 1903.

Four-cylinder engine: Otto cycle: diameter of cylinders, 5 inches: stroke, 6¾ inches, giving full power at 1,200 revolutions per minute: specific gravity of petrol used, 0.68 to 0.70: float carbureter and jet feed: float-chamber fed from petrol tank under slight pressure, about 0.02 atmosphere, which is generated before the engine starts, by means of a hand-pump. While the engine is running the pressure is kept up automatically by means of the exhaust gases, the pressure being controlled by a safety valve. The engine suction operates the petrol-jet and air flows in around the jet and mixes with the spray produced by breaking up the jet on an opposed surface. The volatile petrol evaporates in the supply passages, so that an inflammable mixture of air and petrol-vapor enters the cylinder, without liquid or spray. Both inlet and exhaust valves are positively operated by cams on the "2 to 1" shaft. Ignition is obtained by a rotating electro-magnet, with a contact-break within the cylinder. Arrangements are provided for advancing or retarding the spark, and governing is effected by throttling the mixed charge between the carbureter and the inlet valves. The centrifugal governor can be varied by a lever to control the speed between 300 and 1,200 revolutions per minute. A lever is also arranged to control the throttle independently of the governor.

The cooling is effected by water-circulation and "bee-hive" or "honey-comb" cooler. The water is circulated by a force pump from the water jacket to the cooler, which consists of a multitubular chamber in which air passes through the tubes and water through the spaces between the tubes. The air is forced through the tubes, partly by the motion of the car and partly by a fan which forms part of the engine fly-wheel. Lubrication is automatic from a central distributing vessel, which is kept under slight pressure by the exhaust gases.

The car and its engines were built by the Daimler Motoren Gesellschaft, Cannstadt. This company builds four sizes of engines, viz., 18, 24, 35, and 60 horse-power.

The maximum speed attainable by this car running on the level exceeds 70 miles per hour. While in Algeria in January, 1904, the lecturer had the pleasure of several runs in this car at high speed with the owner, Mr. Mark Dinsmore, and at that time he made a careful inspection of the car and its engines.

Fig. 4. 22 horse-power Daimler petrol engine. The engine was that of one of the gold medal cars in the 1,000 miles reliability trials of the Automobile Club in 1903.

Four-cylinder engine: Otto cycle: diameter, 4 inches: stroke, 5 inches; built by the English Daimler Company.

Fig. 5. Crossley gas engine of 500 horse-power: tandem double cylinder: double-acting: Otto cycle. Cylinders 25 inches in diameter: stroke, 36 inuches: watered pistons, piston-rod and exhaust-valves. The exhaust valves are fitted with balancing pistons which communicate with the cylinders by means of several pivot valves, which are opened just before the exhaust valve is to be opened. This reduces the pressures which come upon the cams, levers, and side-shaft. Magneto ignition. Governing by means of a charge-cut-off piston valve, which is operated by the engine suction. The governor determines the point of the stroke at which the suction operates by acting on a relay valve which admits atmospheric pressure to the back of the piston valve and allows it to operate. By this relay-valve and air-operated control valve the governor is relieved of all heavy work.

This engine is now in course of construction at Messrs. Crossley's works, and it possesses many features of interest in detail arrangements.

So far the number of large gas engines built in England is somewhat small, but Messrs. Crossley have built and sold more than 50,000 gas and oil engines of various sizes—the largest number of any firm in the world.

Fig. 6. "National" gas engine of 300 indicated horse-power: cylinder, 21 inches diameter and 34 inches stroke: 160 revolutions per minute; designed to indicate more than

300 horse-power with 130 pounds per square inch mean pressure. This engine is now being built at the National Gas Engine Company's works.

It is intended to operate on the lecturer's new principle of low flame-temperature and high mean pressure. In large gas engines of ordinary construction the flame-temperature is sometimes low, but it is accompanied by low effective pressures. In this engine the maximum flame-temperature is intended to be about 1,200 deg. C., but the charge-weight is so increased by the addition of air under pressure at the end of the ordinary charging stroke that, notwithstanding low maximum and mean temperatures, the mean pressure is about 50 per cent in excess of the mean pressures usually found. This engine is intended to reconcile conditions which are usually supposed to be conflicting.

The exhaust valve is balanced. The charge-inlet and the gas valves are operated from a transverse shaft driven from the main valve-shaft. Governing is effected by a modification of the usual "hit-or-miss" method. Ignition is by magneto. The front of the cylinder is inclosed so as to form an air-pump. Air is admitted to this pump by an operated valve, and the air is compressed into a water-jacketed chamber which communicates freely with ports overrun by the piston on its forward movement. On one stroke the pump supplies a scavenging charge to displace the exhaust gases, and on the other stroke it supplies air to increase the pressure in the cylinder to about 7 pounds per square inch above atmosphere before the piston closed the ports overrun by it on its compression stroke.

Fig. 7. "Premier" gas engine of 250 horse-power; Otto cycle; cylinder, 24 inches diameter by 30 inches stroke.

The figure illustrates one of the earlier forms of this well-known engine. All forms, however, include the feature of scavenging out the products of combustion from the compression space by means of a charge of air taken in and compressed by a separate pump. The pump is formed by the expanded end of the piston. The piston and exhaust valve are watered, and ignition is by magneto.

Fig. 8. Crossley gas engine of 600 horse-power; cylinders, 33 inches diameter by 36 inches stroke; Otto cycle; opposed cylinder type; watered pistons and exhaust valves; balanced exhaust valves; ignition by hot tubes or magneto. Messrs. Crossley have been manufacturing this type of large gas engine for about five years.

(To be continued.)

UTILIZATION OF WASTE MATERIALS.

UTILIZATION of Amber Scrap. It has been attempted to weld the pieces together by heat; these attempts have not, however, been very successful, as the resulting mass loses much of the beauty of its coloring, being more or less browned by the heat. A better method is the following: The pieces, arranged according to their size, are treated for several hours with solvents, such as carbonic disulphide, ether, etc., whereby a plastic mass is formed. This mass is spread on the table, so that the excess of the solvent may evaporate, and then forced into molds with strong pressure.

In some cases it is advisable to use a moderate heat, in order that the pieces may join better and be more easily pressed into the molds.

This treatment gives the resulting pieces the shape required for their purpose; they are then worked further in the ordinary manner and finally polished.

Whereas the scraps welded together by the old method are very brittle, the pieces obtained by the process just described are remarkable for their great elasticity. Holes may be bored in them without danger of splitting or crumbling, which is extremely liable to happen to pieces welded by heat alone.

To obtain articles with a cloudy or spotted exterior, pieces of hard amber should be mixed with the mass. If these are variously colored, they will give an appearance of originality to the article.

Utilization of Paraffine Waste. The soda lyes which have been employed in purifying the oils contain creosote, part of which is used directly as creosote-soda for preserving mining timber and part worked on for carbonic acid. For this purpose the lyes are saturated with the sulphuric acid, which has been likewise used in purifying the oil, till a strong acid reaction is obtained. In this case sodium bisulphate is formed, which is more soluble and less obstructive to the elimination of creosote than the only slightly soluble neutral salt. The salt lye is set to crystallize and the crystallized salt sold to soda or glass factories.

During the process of decomposition with carbonic acid, obtained, according to L. Grotowsky, from burning coal, the mixture, composed of equal parts of creosote-soda and water, must be cold. Carbonic acid is introduced till the fluid is saturated and has frothed violently for about an hour. The separated soda solution is evaporated till dry, annealed, dissolved in water and rendered caustic with lime; finally the caustic lye is drawn off from the lime-paste and evaporated to 35 to 38 deg. B. The soda-lye prepared in this manner still contains impurities and can only be used for separating creosote from crude oils.

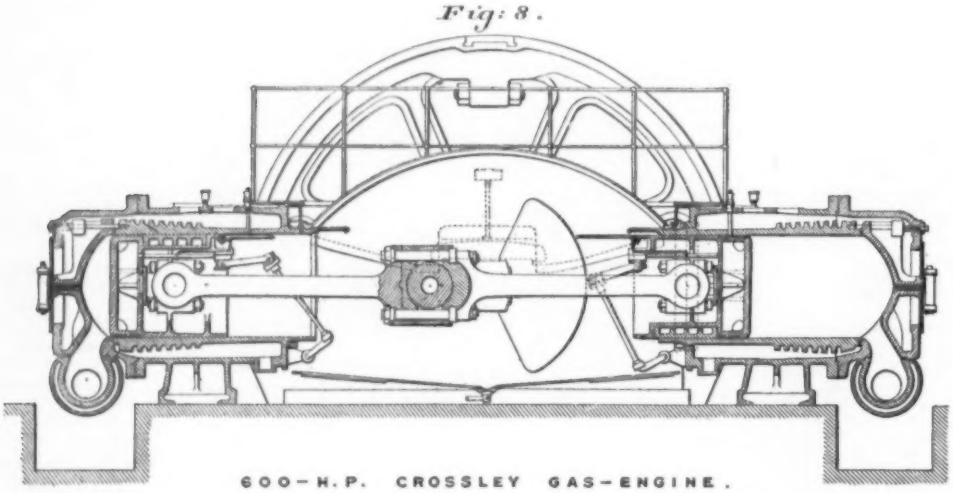
Part of the creosote eliminated by either of the above methods, after being washed in water, is put directly on the market and may be used for preserving telegraph poles, railway sleepers, etc.; also as a disinfectant. When distilled, it yields a strong smelling, thin oil of 0.965 sp. gr.; it is sold under the name of creosote oil and used as a disinfectant or in the preparation of phenol colors. By dissolving repeatedly in soda lye, decomposing with sulphuric acid and rectifying over iron shavings and subsequently over green vitriol, a pure white oil is obtained. The article produced in the mineral oil manufactories of Saxony and sold as creosote, consists, according to Grotowsky, of nothing but phenic acid and cresyl hydrate.

The acid resin drawn off from the mixing apparatus is mixed with hot water in suitable vessels and washed with live steam; when allowed to stand, the empyreumatic resin will then be separated at the top. The eliminated acid, colored black by organic matters, is sold at the strength of 40 to 50 deg. B. to manufacturers of superphosphate and used by the latter in the preparation of phosphorite and animal charcoal. The resin is well washed and, after being mixed with any unused creosote, subjected to distillation, more or less creosote oil being removed according as mineral tar or asphalt is desired.

The animal charcoal used for beautifying the paraffine is boiled out with water, allowed to smolder in horizontal retorts for the recovery of the last paraffine and finally worked into superphosphate.

Utilization of Furrier's Waste. The furrier's business yields a large quantity of waste matter. Some of this may be made into fresh furrier's goods by careful and neat workmanship, but this is the case with only a small proportion. Much of the waste, however, even when it consists of very small fragments, forms valuable material for hat makers; no furrier, therefore, should neglect to keep a basket by his side while operating, as a receptacle for waste, so that the latter need not get soiled on the floor and afterward picked out from a quantity of rubbish. We proceed to give some hints on the various uses to which the scraps may be put.

Fig. 8.



600-H.P. CROSSLEY GAS-ENGINE.

Scraps of gray monkey skin are used as filling for the star-shaped or circular mosaic fur coverings for footstools.

Astrakhan, with the claws and heads carefully fitted together, supplies the material for the coverings for gloves and hunting muffs.

Bearskin scraps of every kind are greatly in demand for the manufacture of paint brushes.

Pieces of beaver and muskrat pelt, even when very small, are in great request with makers of material for hats and fetch a good price. The foreheads of beavers, with the rough part turned in front, may also be used for the front trimmings for furs; large stumps are well adapted for caps. The same applies to muskrat heads, the eyes and ear holes being removed by two longitudinal cuts from the eye to the ear, cut triangularly and put together in the form of a star; linings are also made of the stumps.

Badger. Long-haired pieces, such as fall away from the middle during the process of cutting the covers for knapsacks, form useful material for makers of paint brushes.

Fox. The tails are used in making boas; they are also valuable as trimmings for footstools, footbags, gloves, etc.

Goose and Swan. The scraps are plucked and used as fillings for muffs (down-bags). Powder puffs can be made of the larger pieces.

Grebes. The wings fitted on to the heads or half, small wings may be worked into pretty trimmings for caps of seal and rabbit skin or seal and beaver skin.

Hare. The ears are frequently put together, i. e., placed beside each other on linen and sewn together and used in the manufacture of hunting caps and muffs. This work cannot, however, be recommended. All the remaining parts are taken by the makers of hat material with the exception of the black pieces, which can only occasionally be disposed of to toy makers.

Ermine scraps are often purchased by makers of imitation tails, but only when they are very large and handsome, and when ermine skins are expensive.

Fragments of polecat pelts are bought for making linings. On account of their graceful shape, the heads are adapted for the decoration of hunting muffs, or, cut triangularly, for mosaic covers for footstools. The tails are in demand for making paint brushes.

Rabbit. The heads, if large, are made into cuffs; smaller heads are useful for trimmings. Large sides can often be sewn together for standing collars, etc. The remaining portions, except the black, are used by makers of hat material.

Cat yields but little waste. Good catskins, damaged, are serviceable as tufts in white rabbit-skin muffs. The tails have little value and are seldom asked for.

Lynx. The claws can be worked into cheap trimmings. Otherwise there is little or no waste.

Marten. The foreheads can be used for mosaic covers for footstools. The throats answer the same purpose, and, with the claws, are serviceable for making linings, which are like sable linings, but heavier. The tails are in request for trimmings for fancy goods, also as material for paint brushes.

Mink. The scraps are also sewn together by some. The tails, like marten tails, are much used as trimmings and borders for ladies' dresses, and the foreheads for making fur covers for footstools.

Nutria skin is a favorite material with hat-makers.

Otter. The waste makes excellent material for hats, but the pieces are generally put together, pulled and colored by furriers. The tails, when joined together, make handsome, durable hunting muffs.

Sea-Otter. Good pieces fetch a good price and are sewn together in Russia, principally for trimmings for caps.

Sheepskins. Large scraps are used for linings to footstools.

Raccoon. Rough sides are sewn together to make sleeves, and sometimes linings for furs. The heads are used for the front trimmings on black furs, and durable trimmings are also made of the tails.

Seal. Sealskin scraps realize good prices; even the smallest pieces are sewn together in England for caps.

Skunk. The tails are in demand for paint brushes. White and black foreheads, nicely put together, frequently with triangles of black catskin worked in, provide very handsome trimmings, especially for fox-skin covers.

Goatskin scraps are bought by makers of paint brushes.

To utilize scraps or parings from rough-dressed sheep and lamb pelts, such as those derived from the clothing industry, these scraps are generally first shaved; the short hair finds its way into cloth factories, while the shaved lamb leather is bought by makers of blood-lye salts, tauro-colla and artificial manure. Gawalowski has discovered a method by which not only the wool can be separated, unshortened and practically unweakened, from the leather for spinning and weaving purposes, but the leather itself whenever possible can be obtained in a form capable of being utilized.

If the pelts are placed in moderately concentrated potash or soda lye, the wool will in a short time be entirely detached and a bare greasy skin will remain, which, when well washed in water, yields an excellent material for blood lye salt (prussiate of potash) and tauro-colla factories. The alkaline lye in which the wool has been detached is well adapted for the preparation of ammonia, and in a still greater degree, for the animalization of vegetable textile fibers for the purpose of rapid dyeing in the manufacture of jute carpets and in the weaving of jute furniture stuffs and curtains.

If the pelts are steeped in a concentrated solution of ammonia, the skin will be attacked in such a manner that when the pelts are removed after a time and dried, first in the air and afterward at a temperature of 30 to 40 deg. C., the leather will only appear in the form of pieces of skin which can easily be crumbled. All that then remains to be done is to put the wool in a willow or beating opener and to card it, and we shall obtain on the one hand a wool in an excellent condition for spinning and on the other the leather waste in the form of powdered skin, skin-grits, or flour, supplying a good nitrogenous manure like bone-powder or meat fertilizer.

If the pelts are placed in a moderately concentrated solution of alkaline carbonate, or in a potash solution, they will swell considerably in from two to five days, and the wool can then be easily and completely separated from the moist and flexible skin by suitable means, producing a leather waste similar to that obtained by the first method and a wool as in the second method.

This last process combines the advantages of the first two and is at once the simplest, the most remunerative, and, even down to the mechanical labor involved in removing the wool, the cheapest. Blood-lye salt works, more especially, which dispose of "dry lyes" worked into black potash, can combine this side industry in a rational and lucrative manner with their main business, for in the leather they obtain an excellent ingredient for their mixtures, besides getting their black potash ready nitrogenized, while at the same time they can secure a by no means insignificant profit by reselling the wool.

With reference to the utilization of parchment-paper waste in the preparation of oxalic acid, C. O. Cech reports as follows:

The principal point to be kept in view is the thorough lixiviation of the waste. By the method of making oxalic acid by dissolving sawdust in caustic soda introduced by Roberts, Dale & Co., Warrington, England, the parchment-paper scraps not only yield a plentiful supply of oxalic acid, but are not accompanied by the coloring substances which appear in the working of hard woods.

The process of treating the parchment-paper waste is the same as that employed in the preparation of oxalic acid from sawdust. Further information will be found in the observations on the utilization of sawdust. J. Upmann, however, remarks with reference to Cech's suggestions that the method of converting cellulose into oxalic acid by dissolving with alkalies is not new, since it was established by experiments on a small scale before the introduction of the process of preparing oxalic acid now in vogue; on the other hand, it cannot be denied that the idea of utilizing cellulose for technical purposes in the manner described above has not hitherto been publicly carried into effect. Whether parchment waste is a suitable substitute for sawdust cannot, Upmann further remarks, be decided offhand, for, apart from the question whether a sufficient supply could be procured, the scraps would require pressing to be transported to great distances, complete lixiviation would be attended with greater difficulties than are apparent at first sight, and a subsequent drying of the paper would probably be unavoidable, all of which would involve an expense which would be absent in the case of sawdust, but which might, on the other hand, be more than compensated for by the increased output of oxalic acid.

Utilization of Waste in Button Turners' Shops. A substance for which no use could formerly be found is the lining of the shells whose inner layer consists of the so-called mother-of-pearl, and which lining is cut away by the turning lathe in the process of making pearl buttons. At last the idea suggested itself of converting this waste into fine powder. In this way a delicate bronze powder was produced, having a silky metallic luster, and which could be employed for a variety of purposes, especially as it could take on every shade of coloring. The trituration of this mother-of-pearl waste is performed in the same way as that of wood when reduced to wood-pulp. The waste is ground on a revolving grindstone adapted for the purpose in such a manner that the scraps are first crushed and then put into a cylinder, in which they are pressed against the surface of the grindstone by means of a stamper. The powder thus produced is then washed and when dry put on the market either as it is or previously colored. To reduce mother-of-pearl to a brilliant dust for use in the manufacture of artificial flowers, the shells are first treated in closed boilers with high-pressure steam, after which they can be easily crushed. The use of the powder in making wall-paper is said to give very satisfactory results. For a surface of one square meter 3½ grammes are required, or about 14 grammes of the powder for a roll of 95 x 5 decimeters. The price is 1 pf. per gramme, or 10 marks per kilogramme. Pearl silver is supplied by M. Hess, manufacturer of chemicals in Neufünfhaus, near Vienna.—From the German of Dr. Theodor Koller in Handbuch der rationellen Verwerthung, u.s.w., von Abfallstoffer aller Art.

STANLEY'S SYSTEM OF TRANSMITTING AND UTILIZING LOW-FREQUENCY CURRENTS.

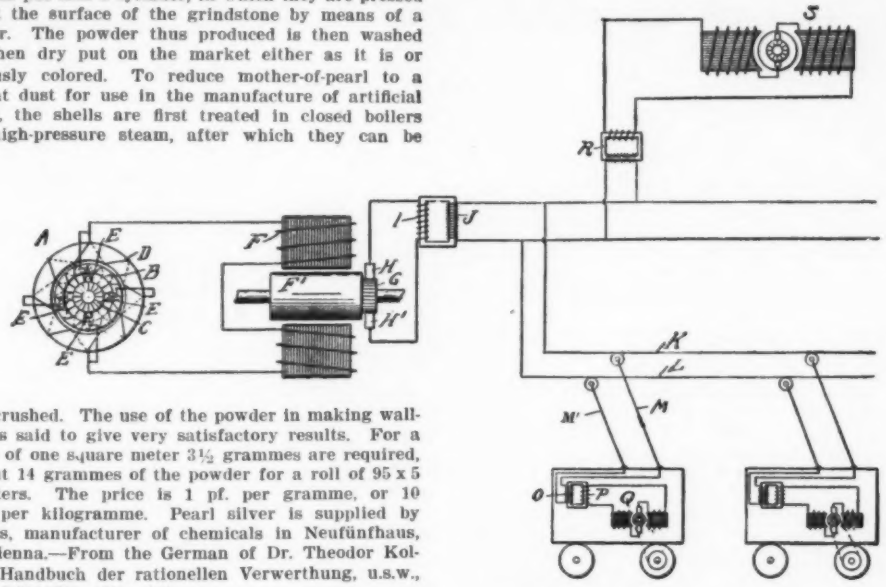
AMERICAN engineers are still firm in the belief that alternating current is best suited for economical transmission over considerable distances. But the utilization of power so transmitted requires the use of expensive transforming apparatus. William Stanley, the well-known inventor of Great Barrington, Mass., has invented "Means and Method of Transmitting Power" in which alternating currents are supplied to alternating-current motors of the direct-current type. The object is to provide a system (particularly useful for electric railways) in which the principal advantages of alternating-current distribution and direct-current motors are present. Mr. Stanley was granted a patent for his invention on April 17, 1906, the application having been filed March 10, 1905. What follows is condensed from the specifications of his United States patent No. 817,998.

If motors of the induction or transformed type are employed it is difficult to cause the time of flow of the field flux and the secondary current to coincide—that is to say, the flux made by the field coils of the motor is not usefully employed at all times or during every part of each wave interval, and a counter-torque effect is set up by reason of this failure to coincide, with the result that the effective torque or effect of the motor, especially at starting, is much reduced below the value that would be obtained if the currents impressed upon the motor were continuous in direction and of steady value.

If, on the other hand, a motor of the commutator type with laminated or divided iron path for its flux is employed with the alternating currents, other difficulties arise, so that only a portion of the electromotive force impressed upon the motor terminals is usefully employed, a considerable proportion being employed in overcoming the self-induction electromotive force of the motor circuit produced by the rapidly alternating current. Moreover, in such commutator motors the conductors of the armature connected to the commutator are subject to induced currents, and these currents not only do not add to the effective torque of the motor, but cause heating of the armature and flashing and burning of the commutator and brushes to such an extent as to render the operation of the motor uncommercial and unsatisfactory.

Again, where such commutator motors are used with the alternating currents it is necessary, in order that the self-induction of the motor may not consume a very great portion of the electromotive force impressed upon it, that the fields or fluxes of the motor shall be relatively weak in comparison with the fields employed with the motor energized by continuous currents, and the design necessitated by the use of such weak fields increases the size and cost of motors and reduces their output.

Mr. Stanley has discovered that by the use of very low-frequency currents—such, for example, between three cycles and 15 cycles per second—motors of the commutator type may be designed of very low self-induction, and therefore free from the trouble arising when motors of the commutator type are used with generators of high frequency, and that the induced currents generated in them will not be sufficient to cause serious heating of the conductors or burning or flashing of the commutators. He has further discovered that these very low frequency currents have the same advantage of distribution as the alternating currents of the frequency heretofore used—that is, the energy can be transmitted by alternating currents of high potential and at the points of consumption transformed by induction into currents of a low potential of the original frequency. In carrying out the invention, he employs alternating currents of a frequency, say, between three cycles and 15 cycles per second, transmitting the energy at high potential and transforming it at the points of consumption into currents of low potential, and there using it to operate motors of the commutator type having laminated or



STANLEY'S SYSTEM OF TRANSMITTING AND UTILIZING LOW-FREQUENCY CURRENTS.

divided iron paths for the flux. This system may be availed of for traction purposes or for transmission in which stationary motors are employed.

In case it is used for traction purposes, Mr. Stanley prefers to locate the step-down transformer on the car whose motor is to be supplied. In this way the advantages of high-potential transmission are preserved without regard to the point on the system at which the car may be. Thus a car remote from the power house will be supplied with energy without the use of any low-potential mains, such as would be necessary in case stationary step-down transformers were used to supply sections of the overhead conductor. The energy would always be transmitted to the car at high potential wherever the car might be. The high-potential transmission system in which the trolley wires themselves constitute the transmission mains enables the transmission to be effected with a great saving in energy when the same amount of copper is employed as would have to be employed in a low-potential transmission system, and if the same loss is to be permitted as would be present with low-power transmission, permits the use of a much smaller amount of copper, and thus saves in the cost of the original installation. It does away with the rotary converters and relies only on the static transformers, which by reason of their simple inductive action do not require attention by an attendant.

Any frequency between three cycles and 15 cycles per minute produces sufficient change of value to enable a current of one potential—as, for example, 10,000 volts—to be transformed to another of a lower potential—as, for example, 500 volts—when applied to closed-circuited transformers, a type of apparatus developing a maximum inductance from a minimum value of current-flow At the same time the transformed currents may, because of their low frequency, be used to energize and operate motors of the continuous-current type of laminated magnetic circuit, a type of apparatus which does not possess as great inductance as do the transformers above mentioned, and do not, therefore, with such low frequencies develop induced electromotive forces of sufficient value to materially change the characteristics and output of such motors from that found when they are operated on continuous-current circuits.

The frequency chosen depends upon the local conditions of the undertaking, but must be so low as not to generate the objectionable electromotive forces and induced currents above referred to.

If currents of a frequency of 25 periods were employed to operate motors of the commutator type, some 20 per cent of the effective electromotive force would be consumed in overcoming the self-induction of the field, while if a current having a frequency of five periods were used only a negligible per cent of the effective electromotive force would be thus consumed. Thus a motor operated by a five-period current and having the same electromotive force of self-induction as another motor operated at 25 periods could have a field strength of total flux $\sqrt{5}$ times as great and a torque $\sqrt{5}$ times as great as the 25-period motor.

In the same manner the electromotive force of self-induction and the induced currents in the armature winding may be reduced to one-fifth their value when five-period currents are substituted for 25-period currents, a condition that reduces the waste energy in such coils to one-twenty-fifth of the amount found at the higher (twenty-five-period) frequency. In fact, the low frequency permits of obtaining substantially the same torque output and operation as may be obtained by motors operated at zero frequency—that is to say, by continuous currents—and yet possesses the advantages of generation, transmission and transformation obtained by employing transformers of the usual type.

A frequency of five periods per second results in currents which are well adapted to the service of electric locomotion where trolley wires are to be supplied with low-potential currents which are to be directly supplied to motors, or to the application of power where it is desirable to use large values of energy in one spot and where, consequently, transformers would be of large capacity. When, however, the power is to be distributed in smaller units of high potential—as, for instance, in the operation of individual motors by individual transformers on a number of cars connected together or singly, in which case the size of the motors and their transformers is reduced—the frequency employed may be advantageously increased from five periods to 10 periods or even 15 periods per second without involving corresponding disadvantages. The general rule is that the frequency employed shall be inversely proportional to the unit of work of the service, a car equipment with its step-down transformer and motor being considered a unit of work.

The increase in frequency permits the use of smaller transformers and a corresponding decrease in the expense of the installation. It must, however, be kept so low as not to develop an objectionable electromotive force of self-induction or to produce large secondary currents in the induced members before mentioned.

Referring to the accompanying diagram, *A* represents a low-frequency exciter consisting of an armature having a winding, *B*, whose coils are connected to segments of the commutator, *C*. *D* is the field-magnet winding of the closed-circuited type, tapped at four equidistant points and connected to brushes, *E*, bearing upon the commutator, *C*.

An energizing winding, *F*, of a low-frequency generator is connected to two of the brushes. The magnetic circuit of this generator is laminated. *F'* is the armature of the generator having a commutator, *G*, on which the brushes, *H H'*, rest. Since the field of the generator is excited by low-frequency currents, low-frequency electromotive forces are impressed upon the brushes, *H H'*, the frequency being independent of the speed of rotation of the generator armature.

The primary of a step-up transformer, *I*, of which *J* is the secondary, is connected to the distributing mains. To the distributing mains are connected conductors, *K L*, supported in any well-known manner, for supplying electrical energy to electrically propelled vehicles. *M M'* are trolleys mounted on top of the car and forming the terminals of the primary, *O*, of a step-down transformer. *P* is the secondary of the step-down transformer connected to the terminals of a series-wound motor, *Q*, having low self-induction and provided with a laminated magnetic path for its flux. The motor is mechanically connected to the wheels of the vehicle so as to propel it.

The system being a constant-potential system, the motors on other cars are connected to the mains by similar devices, the motors on the several cars being in parallel with one another.

It is obvious that other circuits may be connected to the transmission mains so as to supply stationary motors or motor-generators for power, lighting, or other purposes. Thus, for instance, *R* is a transformer and *S* is a motor supplied thereby, the two being similar to the equipment shown and described on one of the electrically propelled vehicles, but connected directly to the mains instead of to other conductors, with which to engage moving contacts.

Toilet Vinegar.—In 20 parts by weight of white vinegar macerate for fifteen days 2 parts of dried rose leaves and 5 parts of triple rose water; when filtered it is ready for use.—Cosmos.

[Continued from SUPPLEMENT No. 1590, page 25474.]

CANALS: ANCIENT AND MODERN.—III.*

ABOUT the year 1757, the Duke of Bridgwater, fully acquainted, no doubt, with what had been effected nearly eighty years before on the canal of Languedoc, in the South of France, and since in different parts of the Continent, conceived the idea of a canal for the purpose of conveying coals from his estates at Worsley, in Lancashire, to Salford and Manchester. His grace profited, no doubt, by the works of that great French engineer, Francis Riquet, and by the advice of that great natural and self-taught genius, James Brindley, whom his grace called off, about the year 1758, from his employment as a millwright and enginemaker in England, to perfect and carry into execution the great important schemes which he had projected. He proposed and brought into Parliament the first act with powers adequate to the great and extraordinary undertaking of cutting a canal of several miles in length, not in the direction of any river or stream of water, but crossing the course of several brooks, roads, etc., and through the lands of a vast number of different persons, all of whom were to be fully compensated, though deprived of the power of withholding their lands or waters, or in any way obstructing the design. In these respects the Duke of Bridgwater has not improperly been called the father of canals in England, while his engineer, Brindley, by his masterly performance on the Duke's canal, altered and extended as the scheme thereof was by three subsequent acts of Parliament, has secured for himself a very high place among the great engineers of this country.

In a very few years after Brindley's death, in 1772, an immense number of navigation acts received the sanction of Parliament, canals began to be freely quoted on the Exchange, and in 1790 the canal mania began. The Gazette of August, 1794, contained notices of eighteen new canals, and the premiums of single shares in companies had reached such figures as £155 (Leicester), £350 (Grand Trunk and Coventry), and £1,170 (Birmingham). Canals began to be used for passenger traffic, and we read in the Times of December 19, 1806, of troops being dispatched from London to Liverpool by the Paddington Canal, *en route* for Ireland, a mode of transport which the writer pointed out would enable them to reach Liverpool "in only seven days"! In the four years ending 1794 some eighty-one canal and navigation acts were obtained, of which forty-five were passed in the latter two years, authorizing an expenditure of over £5,000,000 ($25,000,000).

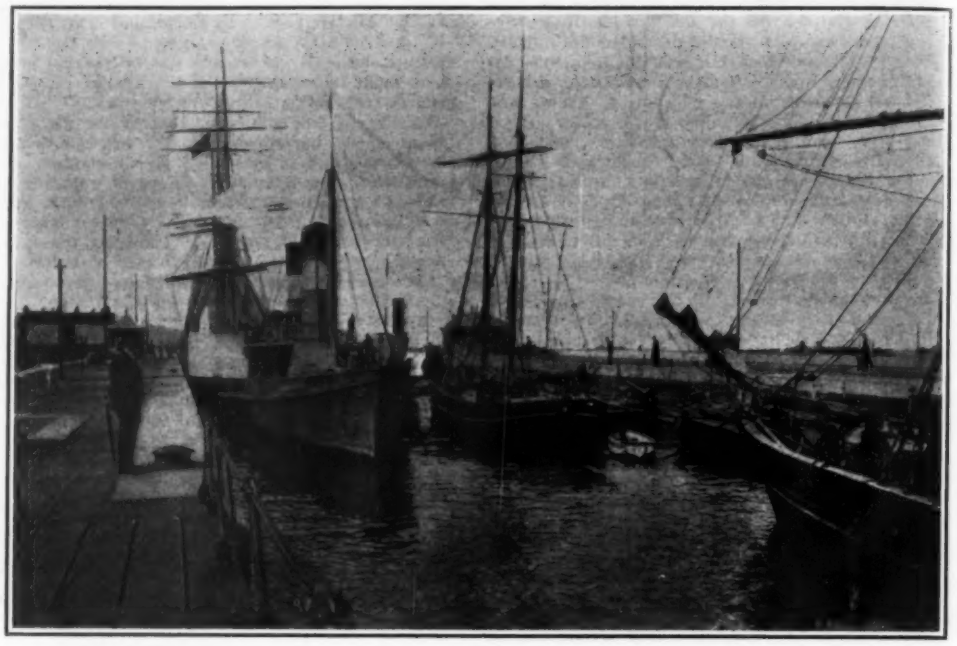
There is no class of property that has undergone a more remarkable range of vicissitudes than canal ownership. In the early days of the nineteenth century the value of canal companies' shares was much higher than that of any railway property has been since that time. The price of some canal shares rose to a hundred times their nominal or par value. Enormous dividends were often paid. In other cases, where the navigation had been neglected, the properties were very lightly esteemed, and yielded unsatisfactory results. The Forsdyke Navigation in Lincolnshire was leased about 1840, by the Corporation of Lincoln, to a Mr. Ellison for 999 years, at £75 a year. Six years later the executors of the lessee leased it to the Great Northern Railway Company for £9,575. The Loughborough Canal shares, which were once worth £4,500, are now scarcely worth £100; and a still more notable decline is that of the Erewash Canal, whose shares, now quoted at about £50, were once worth fully £3,000.

The real commercial prosperity of England dates from the period of canal development and enterprise. Raw materials, manufactures, and produce were easily transported at a reasonable cost between Liverpool, Manchester, Staffordshire, Nottingham, and places on the route to Hull and northern Europe.

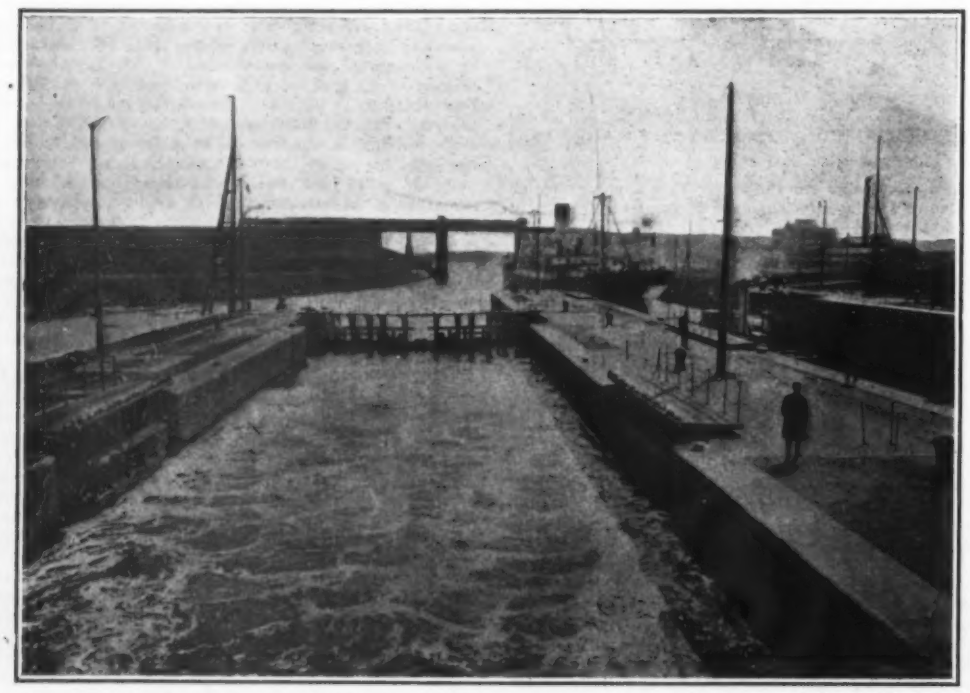
The Leeds and Liverpool Canal, which was commenced in 1770 and completed in 1816, is one of the most important lines of navigation in the United Kingdom, connecting as it does the Irish Sea and Liverpool with the German Ocean, and Hull. The works were extended over a period of about forty-one years, and cost altogether £1,200,000 ($6,000,000). The course of the canal from Leeds is *via* Kirkstall Abbey, Calverley, Woodhouse, Apperley Bridge, Skipton, Blackburn, Wigan, on to Liverpool. It is the longest canal in Great Britain. At Foulbridge there is a tunnel 1,640 yards in length, 18 feet high, and 17 feet wide. Near this tunnel are two reservoirs for the supply of the canal. They cover an area of 104 acres, and store up 12,000 cubic yards of water. The total length of navigation is 127 miles.

Among other canals in England may be mentioned the Kenet and Avon Canal, which starts from the port at Bristol, and runs to Bath, Devizes, Hungerford, Reading, where it joins the Thames for Henley, Marlow, Windsor, Staines, and London. The Ellesmere Canal in North Wales consists of a series of navigations, proceeding from the river Dee in the vale of Llangollen. The Aire and Calder Canal in Yorkshire is connected with the Leeds and Liverpool Canal at Leeds Bridge, and thence communicates with the Mersey at Liverpool. The Lancaster Canal has a course nearly due north. It begins at West Houghton, runs thence to near Wigan, along the course of the Douglas River, by Chorley, and near the road from Wigan to Preston, intersects the Leeds and Liverpool Canal; after crossing a river or two, it passes through a tunnel to Kendal.

In the Midlands there are many existing canals, some of which are still utilized to a large extent. The more important of these are the Worcester and Birmingham, the Birmingham and the Dudley canals. The first of these was constructed under an act obtained in 1791, which authorized the raising of a capital of £180,000 ($900,000) for the purpose. The length of the canal is 29 miles, and it has 6 feet depth of water and 42 feet of top width. The canal is exceptional in passing through no less than five tunnels in its course. The general direction of the Dudley Canal is nearly northwest by a crooked course of thirty miles in Worcestershire, a detached part of Shropshire, and Staffordshire. This canal commences in the Worcester and Birmingham Canal at Selby Oak, and terminates in the old Birmingham at Tipton Green.



THE MANCHESTER SHIP CANAL. THE LOCKS AT EASTHAM, NEAR LIVERPOOL, WHERE THE CANAL ENTERS THE RIVER MERSEY.



THE IRLAM LOCKS OF THE MANCHESTER SHIP CANAL. CHESHIRE RAILWAY AND VIADUCT (MANCHESTER TO LIVERPOOL LINE) IN THE BACKGROUND.

Advantages and Disadvantages of Canals.—The principal advantages afforded by canals are thus concisely stated by Gen. Rundle: (1) They admit of any class of goods being carried in the manner and at the speed which proves to be most economical and suitable for it, without the slightest interference with any other class. (2) The landing or shipment of cargo is not necessarily confined to certain fixed stations, as is obligatory on railways, but boats can stop at any point on their journey to load and unload, and discharge their cargoes direct over the ship's side. (3) The dead weight to be moved in proportion to the load is much less. (4) The capacity of traffic is practically unlimited, provided the locks are properly designed. (5) There is no obligation to maintain enormous or expensive plants or establishments, as all those can, and would be, provided by separate agencies and distinct capital. Thus a large outlay in first cost and subsequent maintenance of rolling-stock is avoided. (6) There is an almost total absence of risk, and the reduction of damage to cargo in transit, and consequently of insurance, to a minimum.

On the other hand, the defects besides those of original construction, in existing British canals are: (1) A total absence of any unity of management. (2) A want of uniformity of gage in the locks, as well as in the canals themselves. (3) With few exceptions they are not capable of being worked by steam. (4) An unequal system of tolls. (5) The many links in the communications in the hands of the railways paralyzes any unity of action, and renders any scheme of amalgamation between the several lines impossible.

* London Engineer.

THE DE PLUVY DIVING DRESS.

A NOVELTY in the way of diving apparatus is the invention of M. de Pluvy, a prominent hydrographic engineer of Paris. As he has had many years' experience in diving operations, there is no doubt that the apparatus is of practical value. He uses a metallic diving suit which is made somewhat on the plan of the ancient coat-of-arms, being built of light and strong sheet metal having a thickness varying from 0.2 to 0.3 inch according to the position of the pieces. The joints and coupling points are made of pressed leather and rubber, and a special form of hydraulic joint is employed. On the top of the armor is fixed the helmet, which is the principal feature of the apparatus. The air is not brought to the diver from the outside, as usual, but the air he breathes is sent by a tube into a special regenerating chamber containing certain chemical products which renew the supply of oxygen and the air is then sent to the interior of the helmet by another tube. The air-renewing apparatus is contained in a pair of cylindrical chambers attached to each side of the helmet. Regulating valves keep the air pressure within the helmet at the right amount and always constant, no matter

what the depth may be below the surface. Mounting and descending are carried out by a drum and cable worked by an electric motor. At the same time the cable serves to carry the current which is needed for the respiratory apparatus. The diver communicates with the surface by a telephone, and a number of wires run from the armor up to a set of colored lamps, showing how the different apparatus is working. There are many advantages to be secured from the new apparatus, and we expect to give a more complete and illustrated description of this interesting device. M. de Pluvy has personally been able to go down to a great depth, and during the 115 descents which he has already made with the new diving suit he reached depths varying from 150 to 300 feet. This far exceeds the depth to which an ordinary diver can go.

UNLOADING FOREIGN CATTLE ON THE MANCHESTER SHIP CANAL.

CONCRETE AS A ROOFING MATERIAL.

CONCRETE foundations, walls, and floors have been employed for some time in the construction of buildings. More recently this material has been utilized for roofing with great success. Concrete has now entered every field of the building industry, its general adoption being due to the increasing prices of other building material and to the great ease with which concrete is worked. The structures into which concrete enters extensively are the only ones in recent years which have been finished according to schedule, as most, if not all, of the labor troubles encountered with the workers in the various branches of the building art are overcome by the use of concrete. Skilled labor is largely dispensed with. The mixing of the material is done according to fixed rules, which are modified in accordance with the character of the work in hand. The mixing is done under the eye of a skilled engineer, who can superintend a great deal of this kind of work, and at the same time give some of his attention to the matter of making a test of the material before and after mixing, which is quite necessary.

In the matter of roofing, concrete has been made use of only in a few instances, and in these it has been applied in much the same manner as in flooring. A departure has been made recently from this method in the construction of a new power plant at Chittenden, Vt., where it has been placed on the roof in the shape of slabs which were formed on the ground, a suggestion which originated with the engineers, J. G. White & Co. Strength is not a consideration, as in the construction of flooring, and it was decided that a cement slab reinforced with expanded metal would answer all purposes. This method is more convenient and economical than the monolithic process, in which the cement is put in place in a moist condition and allowed to set in its final resting place.

For the roof slabs of this power house a size of 9 feet 6 inches by 4 feet by 3½ inches thick was decided upon, and the slabs were formed in heavy wooden molds. To give a smooth interior finish a layer of neat cement was laid on the bottom of the form to the depth of one-half inch. Upon this first layer was spread the sheet of expanded metal, with a margin of two inches over the dimensions of the slab all around. In order that this margin might not interfere with the forming of the slab, the forms were made in two parts, the upper part being placed in position after the sheet of expanded metal was laid on, the remainder of the slab being then completed with a rich concrete in the proportions of cement, one; sand, two; and stone, three. The stone was screened through a sieve of one-half inch mesh. Finally the concrete was well tamped, and the upper surface roughly finished with a trowel. At the end of a week the slabs had so far dried out as to permit their being lifted to the roof.

The roof trusses of the building are 9 feet 8 inches from center to center. The slabs were fixed in position by rods driven vertically between the upper angles of the trusses, and passed through the overlapped ends of the expanded metal in adjacent slabs. Finally, the spaces left between the ends of the slabs were filled with rich concrete and tamped. The joints between slabs in the same vertical section were pointed up with cement, and the roof was then ready for waterproofing.

CONTEMPORARY ELECTRICAL SCIENCE.*

DISTILLATION OF COPPER.—H. Moissan points out that the electric furnace has disposed of the assumption that there are any truly refractory bodies, and has proved that all solid bodies are capable of assuming the liquid and the gaseous states. Some bodies are decomposed before they liquefy, but on the other hand new compounds are also formed, like the newly-discovered carbides, borides, and silicides. The author has lately studied the boiling point of copper and the best manner of distilling it at atmospheric pressure. He placed 300 grammes of pure copper cut into small cylinders into the crucible and conducted a copper tube cooled by a rapid current of water through the furnace to condense the copper volatilized by the electric current. An alternating current of 300 amperes at 110 volts was employed, and was applied for 8 minutes, after which it was found that 233 grammes of the metal had been volatilized. Boiling commences in about 3 minutes. The condensed copper is found on the copper tube in the shape of a felt consisting of copper filaments. Each filament has minute iridescent branches which make the mass look like velvet. The felt consists of pure copper. But at the boiling point copper dissolves some carbon, yielding it up again on solidifying in the form of graphite.—H. Moissan, Comptes Rendus, November 27, 1905.

AUTO-ANTI-COHERER.—P. Lohberg describes an automatically-working anti-coherer which has some resemblance of De Forest's responder. The anode consists of a plate of silver the size of a shilling, attached to an ebonite block and earthed. In the center it is higher, and a piece of silk gauze is stretched over the excrescence by an India-rubber ring. The gauze is moistened with glycerine, and a piece of silver-chloride or other photographic paper is placed on it, with the film toward the gauze. This anode is faced by a cathode, consisting of the bottom plate of a plunger, whose height can be minutely regulated. It is inclosed in ebonite, and near its circumference are mounted a number of gramophone points. The instrument is put in series with a voltaic cell, a rheostat, a galvanometer and a horseshoe telephone. The gramophone points are gently pressed against the anode, and partly released, leaving delicate bridges through the glycerine and silk. These are destroyed by Hertzian waves, but re-established when they cease. By suitably regulating the gap the restoration can be made instantaneous. The author has made a special contrivance for renewing the glycerine or other liquid. He does not give a theory of the processes involved, which he believes to be very complicated.—P. Lohberg, Annalen der Physik, No. 14, 1905.

* Compiled by E. E. Fournier d'Albe in the Electrician.

SETTING CONCRETE SLABS ON A POWER HOUSE ROOF BY MEANS OF A DERRICK.

CONCRETE SLABS FOR POWER HOUSE ROOF DRYING OUT.

PREPARATION OF MODERN CEREAL BREAKFAST FOODS.

UNTIL recently, when the cereals were intended for porridge, they were, as a rule, simply husked and more or less crushed. Such products required long, slow cooking, and were hardly convenient for those who could not keep a fire all day. The earliest of the cereal breakfast foods which came into general use in the United States were of this class, oats being the most commonly eaten. Coarsely ground uncooked wheat does not seem to have been so generally used for preparing a breakfast dish, though corn meal and hominy have long been and still are popular. As the use of cereal breakfast foods became more common, the raw products were to a considerable extent replaced by the so-called rolled oats and wheat, in which more or less of the cooking had been done at the factory, and these goods are commonly conceded to surpass the simpler and old-fashioned raw products in ease of preparation in the household and in other ways. The manufacturers claim that the malted and otherwise specially prepared goods, which are a later development, represent a still further advance. These specially prepared cereals are usually sold in packages under proprietary names, which may or may not indicate their real nature. The methods of preparation vary greatly, and the exact details of processes are, of course, the secrets of the manufacturers. However, enough is known to give a fairly correct idea of the processes.

According to Dr. Charles D. Woods and Prof. Harry Snyder, who have recently issued a bulletin on the subject for the U. S. Department of Agriculture, the grains are usually very carefully cleaned. Ingenious devices have been invented for removing foreign seeds, dirt, and other substances which may have found their way into the grain. The husk or glumes of such grains as oats, barley, and rice are very thoroughly removed, so that the amount left in is much smaller than formerly.

Among the first of the modern preparations to be introduced were the "rolled" grains. To make these the husked grain is cooked for some time by steam and while still wet is run between rollers and pressed into thin flakes. After drying, the product is ready for marketing. Such rolled grains usually do not pretend to be more than partly cooked and are supposed to be thoroughly recooked before serving.

The ready-to-eat brands are prepared in a great variety of ways. Some are probably simply cooked in water and then dried and crushed; some are made of a mixture of different grains; some have common salt, malt, and apparently sugar, molasses, or other carbohydrate material added to them; some probably caramel or other similar coloring matter. Those with a flake-like appearance are made like rolled grains, save that the cooking is continued longer. Those which look like dried crumbs are probably made into a dough, baked, crushed, and browned. The shredded preparations are made with special machinery which tears the steam-cooked kernels into shreds and deposits them in layers or bundles. Very many of the ready-to-eat cereals are parched or toasted before packing. This gives them a darker color, makes them more

crisp, and imparts a flavor which many persons relish.

In the so-called "malted" or "predigested" preparations malt or some similar substance is added during the process of manufacture. Malt, it will be recalled, is grain (usually barley) allowed to germinate until a ferment called diastase is developed, and then kiln-dried. This ferment, like some others, has the power, under certain conditions, of changing starch, which is insoluble in water, into various soluble forms, such as dextrin, isomaltose, and maltose (sugar of malt). These soluble forms are more easily acted upon by the digestive juices than the original starch. How much starch is actually changed in the malted cereals and how desirable it is to have it so changed outside of the body are questions to be considered.

Some of the cereal foods have apparently been cooked by dry heat only. In the case of puffed rice, which suggests popped corn somewhat in flavor and texture, it is said that the expansion of the grain is caused by heating it under pressure at a fairly high temperature and then suddenly diminishing the pressure.

In comparing the new cereal preparations with the old-fashioned ones we must not forget the neatness with which they are now put up. It was hard to tell what might have happened to some of the old brands. They were often ground from imperfectly cleaned grain, in small and inconvenient mills where it was hard to keep out dirt, and were very commonly sold from bins and barrels into which dust could easily find a way. In the modern mill cleanliness is found to be the best policy, and the neat, almost air-tight paper and cardboard packages in which the foods are sold are, as a rule, an assurance to the purchaser that they reach him as clean and fresh as they left the mill. In some of the manufactories the preparation of the cereal food seems almost perfection as regards cleanliness.

For convenience in transporting and handling, as well as to insure absolute protection from moisture and from air containing dust and germs, some cereal breakfast foods are marketed in sealed tin cans. The cans are evidently filled under pressure and consequently the cereals occupy relatively a small amount of space per pound. In provisioning camps, expeditions, etc., the small bulk and the fact that such goods cannot be so readily damaged by water might prove an advantage.

INFLUENCE OF LIGHT AND HEAT ON GERMINATION.*

By CLEVELAND ABBE.

PAUCHON (1880) summarizes the results of the studies of many authors on the relative influence of light and heat on the germination of seeds and the growth of plants. The following is condensed from him:

Edwards and Colin (1834) state that in their day little was known as to the influence of light and air on the green matter and on the respiration of plants; since then, however, it may be considered as established that the life of a plant varies in proportion to the adaptation of the plant to its surroundings. The study of the influence of light may be said to have begun with Lavoisier, who thought that the light directly combined with certain parts of the plant producing the green leaves and colored flowers, and that without light there could be no life. Similarly Moleschott (1856), at Zurich, affirms that in general everything that breathes or moves draws its life from the light of the sun.

Boussingault (1876), controverting a statement of Pasteur, maintains that the growth of mushrooms and mold in the dark is not an exception but a confirmation of the general rule, and that if the solar light should be cut off both the plants having chlorophyl, and also the plants that do not have it, would disappear from the surface of the globe.

Berthelot, in his essay on the mechanics of chemistry as based on thermochemistry, shows that the action of the light is demonstrated by the formation of complex chemical effects, isomeric changes, and more complex reactions. For instance, the combination of free oxygen is stimulated in a great many cases by the action of light, as is shown by the bleaching of fabrics of any kind exposed to the air and by the oxidation of volatile oils. All the oxidizing in reactions brought about by the action of light is exothermic—that is to say, there is a loss of energy in the transition from the compound body to its elementary components and a disengagement of heat. The light plays the rôle of a determining agent. On the other hand, when a complex body is built up in the cells of a plant, by drawing in elementary bodies from the atmosphere and soil, the reaction is endothermic, and solar heat is absorbed and rendered latent in the plant.

Sachs, Wiesner, and Mikosh would seem to have established the principle that the formation of the green matter of a plant is not dependent wholly on the light as such, but also demands a certain temperature, varying between 0 deg. and 35 deg. C., for the various plants of Europe. They show also that an increase in the temperature of the atmosphere, with equal increase of light, increases the rapidity of the formation of the chlorophyl up to a certain maximum temperature, and that in proportion as the temperature departs from this favorable maximum, either above or below, the formation of the green matter becomes less and less active, until when the limits 0 deg. or 35 deg. C. are exceeded it ceases altogether. But the temperature most favorable for the formation of chlorophyl under the action of light has but little connection with the temperature that promotes the further action of the chlorophyl after it has been formed within the plant. Thus Timiriazeff (1880) shows that the activity of the chlorophyl consists in the absorption of certain radiations; but in order that these radiations may act it does not suffice merely that they should be absorbed; it is further necessary that there should be a very considerable intensity of heat, in order to furnish to the chlorophyl the definite number of calories necessary for the decomposition of the carbonic-acid gas taken in from the atmosphere.

In general, under ordinary conditions light is indispensable to the formation of chlorophyl. To this general law there are a few apparent exceptions, as follows: The embryos of the genera *Pinus* and *Thuya* have their cotyledons colored an intense green at the moment of germination, even when they have been or appear to have been completely deprived of the action of light. So also with a certain number of phanerogams in which the embryo is protected by thick integuments; finally, the fronds of certain ferns have a green color, even when they grow in complete darkness. With regard to the seeds of *Acer*, *Astragalus*, *Celtis*, and *Raphanus*, it has been shown by J. Böhm that when they germinate in darkness they do not acquire any green color; Flahault (1879) has obtained the same result for the seeds of the *Viola tricolor*, the *Acer pseudoplatanus*, and the *Geranium lucidum*. Similarly as to the other seeds above enumerated the studies of Sachs and Flahault render it probable that in most cases there was stored up in the seed certain reserve nutrition, which reserve, originally formed under the action of light, can subsequently in the act of germination temporarily replace the further direct action of light. It would thus seem that in no case can dark heat truly replace the action of sunlight.

On the other hand, light can replace heat in the process of vegetation. This was first shown by De Candolle, and a striking illustration is quoted by Moleschott (1856), who shows that by the influence of light during the resplendent nights of the polar regions the harvests ripen in a short time, while many days of our autumn heats in lower latitudes scarcely suffice. It is the quantity of light and the quantity of the radiations that these plants receive that enable certain cereals, such as barley and oats, to be cultivated as far north as 70 deg. of latitude. The observations of Schleiden on the potato, of De Candolle on the radiola, and of Haberlandt (1866) on oats, show that there exist decided differences in the quantities of heat necessary to the development of different species of vegetables under different latitudes, and that the most important cause of these differences is the quantity of light which these plants receive. De Candolle, in his botanical geography, says the effect of light is shown in the northern limits of certain species; thus the radiola is perfected by a total supply of heat represented by 2,225 day-degrees in the Orkneys at 59 deg. north, but by a total of 1,990 day-degrees at Drontheim, latitude north 63 deg. 25 min.; the difference (235) corresponds to the fact that the longest day is 1¼ hours longer at Drontheim than in the Orkneys, which increased sunlight enables the plant to complete its growth better under the same temperature.

Wheat furnishes a still more striking example. It begins to vegetate when the temperature in the shade is about 6 deg. C., and observation has shown that it requires the following day-degrees to ripen: At Paris in 138 days, total shade temperature 1,970 deg. C.; at Orange, 117 days, total shade temperature 1,601 deg. C.; at Upsala, 122 days, total shade temperature 1,546 deg. C.; at Lynden (North Cape), 72 days, total shade temperature 675 deg. C. Or, if we use, not the shade temperatures, but those of a thermometer exposed to the full sunshine, as is done by Gasparin, then the above figures become at Orange, 2,468 day-degrees; Paris, 2,433 day-degrees; Lynden, 1,582 day-degrees. These remarks of De Candolle with reference to germination are equally applicable to the whole period of growth of the plant.

As to the method of calculating the sum total of temperatures De Candolle found that it may be conducted in two ways, either by adding together all the mean daily temperatures above 0 deg. C. or by omitting the useless degrees and adding all the others. This last method would seem to be the most logical, but can rarely be employed, owing to our ignorance of that minimum temperature below which all must be omitted. On the other hand, if we consider that a plant which vegetates between 10 deg. C. and 30 deg. C. has a maximum at 20 deg C, and if we seek the coefficients of growth corresponding to each successive degree of temperature, we find, as Boussingault has shown, that these coefficients vary for each degree as we depart above or below the temperature most favorable to vegetation.

Similarly De Candolle (1865) has shown that near the minimum and near the maximum temperatures the rate of germination is more difficult, and therefore slower, than at the intermediate or best temperatures; consequently, both in germination and in subsequent vegetation, it is necessary to recognize the fact that calculations of the sums of heat in connection with the study of the geographical distribution of plants are complicated with hypotheses and many sources of error.

Schuebeler (1862) shows that cultivated plants in northern countries have more highly colored flowers, larger and greener leaves, and larger seeds, which are more highly colored and richer in essential oils, than those of southern regions. Bonnier and Flahault (1878) have shown the same facts for uncultivated plants. Both these authors attribute this result to the prolonged action of sunlight, and the latter shows that the variations are exactly proportional to the duration of sunlight. In Flahault's more recent observations he shows that there must necessarily exist a relation between the quantity of carbonic acid decomposed and the quantity of carbonaceous matters formed by the plant, and that in general the sunlight has a very remarkable influence on vegetation since it compensates in a large measure for the deficiency of temperature.

It is, furthermore, to this influence of light that Pauchon attributes the singular fact that plants cultivated in high latitudes are endowed with a vegetating power greater than that of southern countries, so that when transported to the south their seeds ripen sooner than those of the southern plants. This subject has been especially studied by Tisserand in his memoir on vegetation in high latitudes, as cited by Grandeau in his work on nutrition of plants. According to Tisserand a plant behaves in northern latitudes as a more highly perfected machine and one that performs better than southern plants. In regions where it has neither time nor heat it gains in activity and in the speed with which it perfects its own growth. It seems to Pauchon that we may properly interpret this phenomenon if we admit that a seed transported from the north to the south finds itself in climatic conditions more favorable to the development of the embryo which it contains and of the plant which is to follow. What the action of light loses in duration in proportion as we move toward the equator it gains in intensity. It may be that the cause of this increased activity is due to the larger size of the northern seeds or to their greater richness in the essential oils. Pauchon thinks that the embryo of such a seed should not be compared to a more perfect machine; it is rather an identical machine, but better nourished by the reserve of combustible and nutritive material in the perisperm. Possibly the abundance of essential oils contained within the seed contributes to furnish to the embryo in northern countries the materials for the oxidation that is necessary in order to maintain its temperature during germination and to struggle against the severity of the climate.

Tisserand (1876) has shown that the rye cultivated in northern Norway has not the same chemical composition as that of France and Algeria, and that in general, as we go northward, or as we rise above the level of the sea, or as the temperature lowers without diminishing the quantity of light, we see the starch in the grain increase relatively to the nitrogenous components. Wheat grown at Lynden (North Cape) has a smaller proportion of gluten than the wheat of France, and the latter less than the wheat of Africa. On the other hand, barley raised at Alten, on being sown at Vincennes on the 7th of April by Tisserand, was ripe on the 18th of June, or thirty-seven days in advance of French barley, so that in order to mature it required a sum total of heat far less than the French barley. The reverse is true when southern grains are carried north and sown in colder climates. Therefore, as Marie-Davy has remarked, plants become acclimated more or less rapidly according to their own nature and the extent of the climatic variations that are imposed upon them; the climate produces in them a functional change which corresponds to an organic change, the nature of which often escapes our observation. It is therefore not necessary that each phase of vegetation should correspond to a constant sum of heat in very different climates. That which it is important for us to know is what are the limits between which this sum total can vary, for the same species of plant under different climates.

The general fact that the quantity of nitrogen contained in the seeds increases as we approach the warmer climates leads to the hypothesis that the formation of albuminous reserves within the seed takes place in proportion to the temperature, and that the formation of starch and other reserves takes place in proportion to the duration of the light and the action of the chlorophyl of the leaves. As we pass from the pole to the equator the luminous intensity of the sunlight increases from a hundred to a thousand, but its duration diminishes during the growing season from a hundred at the poles to fifty at the equator. Among the special investigations into the action of sunlight we note that of Timiriażeff (1877), who has shown that a very intense light, after traversing a certain thickness of green-leaf cells, has no further action on the phenomena of the reduction or decomposition of carbonic-acid gas; in other words, it acts the same as darkness would do. On the other hand, Paul Bert, by exposing plants to the action of light which had been sifted through a solution of chlorophyl, invariably found that the development of the green matter of the leaf was completely arrested; inversely, he found the green matter produced to its normal amount when the plant received only light that had been filtered through a solution of iodine in bisulphide of carbon, which solution, as we know, cuts off all visible rays, but allows the red and infra-red to pass through with great freedom. This would seem to demonstrate that chlorophyl is formed by the action of the red portion of the spectrum.

As to the effect of light on the germination of seeds, Pauchon (1880) gives a critical summary of views by different authors, from which we condense the following:

Miesse (1775), from observation on the Camelina (*Myagrum sativum*), concludes that the seeds grow in darkness the same as in full daylight, and that light does not seem to influence this stage of vegetation.

Sénébier (1782), from observations on seeds of lettuce and beans, some of which were exposed to the

* Abstracted from Bulletin 30 of the United States Department of Agriculture.

full sunlight, others to sunlight after filtering through a thickness of water, others in the dark, and others in red, violet, and yellow light, respectively, reached the conclusion that light was injurious; but his results were not decisive, because of his neglect to observe exactly the temperatures under different conditions.

Ingenhousz (1787) exposed an equal number of mustard seeds in places receiving different amounts of light. He himself concluded that the light of the sun is as injurious to vegetation at the beginning of its life as it is advantageous to vegetation in the fullness of its life. But a more careful consideration of Ingenhousz's experiments shows that the moisture and the temperature in his several localities varied so much as to prevent any serious conclusion as to the action of light itself.

Bertholon (1789), in an article on the effect of electricity, shows that up to that time it had not been proven whether the germination of the seeds was affected by light or by humidity. His own experiments convinced him that the latter was more important.

Sénébier (1800) made additional experiments on peas and beans, sowing them in sponges, which were kept equally moist, all inclosed under glass covers, so that no evaporation could take place. Some were exposed to sunlight and some were kept in the dark, but those which were in the dark germinated much sooner than those in the light. But in such experiments as these the sources of error are numerous, and the fact that there was no renewal of the air under these covers was especially unfavorable to germination. In fact, Leclerc (1875) has shown that under the influence of mercurial vapor, as it existed in Sénébier's experiments, a large portion of seeds are killed, so that with our present knowledge we can not accept Sénébier's conclusions.

Lefébure (1800), having finally accepted the conclusions of Sénébier and Ingenhousz relative to the injurious influence of light on germination, repeated the experiments, but also observed the temperatures more carefully, and in addition sought to determine the effect of light that had passed through plates of white, green, black, red, and blue glass; but he added little to our knowledge, although he himself concluded that the seeds under white glass were retarded.

Th. de Saussure (1804) endeavored to ascertain whether the influence observed by others was due to light or heat, and he concluded that nothing demonstrates that light has an injurious influence independent of the heat that accompanies it.

Keith (1816) made no observations himself, but controverted the conclusions of De Saussure.

Boitard (1829) sowed the auricula seeds in three flower pots, but the conditions as to temperature and moisture are not sufficiently known to justify us in drawing any conclusion.

A. P. de Candolle (1832) says:

"I do not deny that darkness may be useful in germination, but I do deny that it is necessary to think that light has no action on germination. Analogy indicates this, theory confirms it, and experience demonstrates it."

According to De Candolle, light favors the decomposition of carbonic acid, but germination demands the formation of carbonic acid; therefore darkness will favor germination. This theory thus enunciated by De Candolle has been accepted by many authors without proper experimental basis.

Ch. Morren (1832) experimented upon water cresses grown under different colored glasses. He concluded that as darkness favored germination, so the individual colors of the spectrum, acting each by itself, have a special influence that favors germination in such a way that those colors that have the greatest illuminating power are those that least favor germination.

Ad. Brongniart (1832) announced as the results of his experiments that the retarding influence of light depends not only on the illuminating power of the colored light, but on the relative quantity of white light that passes through the different colored glasses. In all these experiments the seeds were several millimeters below the surface of the soil, so that the colored lights did not affect the seeds directly, but indirectly through the soil whose temperature and moisture and evaporation may easily be of predominating importance.

Ph. A. Pieper (1834), Meyen (1837), Zantedeschi (1846), and Belhomme (1854) have all experimented on the growth of seeds under colored glasses; but the sources of error incident to this method of observation prevent us from drawing any conclusion as to the influence of light itself.

Ville (1865) says that the injurious effect of solar radiation on germination is the result of the heat only and that the effect of the light is inappreciable. For aquatic plants whose seeds germinate in the water, darkness seems decidedly favorable to germination, but it acts only in an indirect manner by preventing the warming of the water and the disengagement of the oxygen that is dissolved in this water.

Charles Darwin (1877) says that certain species of seeds do not grow well when they are exposed to the light, even the diffuse light of a room.

Duchartre (1877) considers the action of darkness as a secondary influence, useful but not at all essential and concerning which there has been too much exaggeration.

Faivre (1879) has shown that the appearance of the primordial latex occurs at a moment when the radicle is only a few millimeters long and when the cotyledons are still inclosed in the seed envelopes and have not yet received the action of light. He notes that under a yellow light obtained by transmitting sunlight through a solution of bichromate of potash the seeds develop their chlorophyl and their latex more rapidly, and consequently have a shorter period of germination than under a blue light obtained by transmitting sunlight through a solution of the ammoniacal oxide of copper.

Detmer (1880) has consecrated an extensive work to the study of the germination of seeds, and states that concerning the action of light we are still ignorant as to whether it is direct—that is to say, whether it stimulates the storing up of new substances in the vegetable tissue or whether, on the contrary, it strengthens the persistence within the cells of some special process having a more or less intimate relation to the phenomena of growth and which can only proceed in darkness. Detmer adds a few historical references, viz., Humboldt (1794), according to whom seeds sprout more easily in darkness than in light; Fleischer (1851), Heiden (1859), and Nobbe (who all consider solar rays as having no action on the seeds), and, finally, Hunt (1851), who considers that light retards germination.

(To be continued.)

SCIENCE NOTES.

In the bacterial purification of sewage the work is carried out by natural agencies in what may be broadly regarded as two distinct operations. The first stage consists of the elimination of the grosser suspended solid matters from the sewage as brought about by screening, by subsidence in detritus tanks, and by the reduction of the remaining solids by anaërobic bacterial action in the septic tank. The second operation consists of the conversion of the dissolved impurities contained in the sewage or septic effluent into stable and inoffensive forms. The remaining part of the work of purification is brought about by aërobic bacterial action either upon "contact" beds or "percolating" filters.

The systematic botany of America to-day is, in some respects, in an almost irretrievably chaotic condition, and this condition is unquestionably due to the use of the various manuals which have been published down to the present day. Local workers everywhere determine the names of plants by comparison of six- or eight-line descriptions, and issue floral lists, make botanical surveys, frame ecological deductions, separate "new species," work out histological and embryological details, carry out important physiological experiments—everywhere using these manual names to label their observations; and this is the framework over which the whole tissue of American botany is spread. A remarkable feature of all this is that any plant from any region can always be crowded in under some name found in the pages of the manual, or the six- or eight-line descriptions can always be interpreted so as to cover any plant.

Studies may well be made dealing with the relation of nutrition to toxic agents, the effects of temperature and other conditions upon such action, and the accommodation of organisms to increasing strengths of deleterious agents. Naegeli's work on the oligo-dynamic action of copper is beginning to be appreciated and in one way or another the results have in recent times been repeatedly confirmed. In most cases, however, no allowance has been made for the action of the nutrient salts which may be present in the culture fluid and which may affect in a very dissimilar way two different electrolytes. In this connection it is only necessary to call attention to the toxic action of certain compounds of mercury, in which increased toxicity, due to the presence of small amounts of some other salt of the same acid as the mercury salt used, is indeed quite remarkable. Within the past few months an unusually interesting paper has appeared in which Kanda reports the action of certain toxic agents upon plants grown in pots as compared with those plants grown in water cultures. His important conclusions are as follows: (1) A strongly dilute copper sulphate solution, even 0.000,000,249 per cent, is injurious to seedlings of the common garden pea in water cultures; and neither a solution ten times nor one a hundred times more dilute produced any stimulative effect. (2) In pot experiments with soil, the same seedlings are uninjured when watered twice a week during a period of from five to eight weeks with a solution of 0.249 per cent; in other words, even after from five to seven grammes of copper sulphate were present in each pot. No explanation is offered of this remarkable diversity of action, but within the past few months another paper has appeared which may throw light upon the results given. True has ascertained that finely-divided paraffine, quartz sand, filter paper, or other insoluble substances are all found to reduce the toxic action of the deleterious salt. It is explained on the assumption of an absorption of the toxic molecules by the surface of the insoluble particles. Increasing the number of grains of sand, for instance, in any toxic solution produced the same effect as increasing the dilution. From the results of these two papers it would seem, therefore, that we have two entirely different sets of conditions to deal with when any test of such action is made in water cultures, on the one hand, and in soils, on the other. If Kanda's results are confirmed, an extensive series of tests with both fungi and higher plants should be made in order to determine some relation which may give a working basis for further comparisons. In fact, much of the work thus far done will have to be re-examined in the light of these results, for if any precipitate or other solid particles have been present in the solutions, an error will enter into the calculations. The question will also arise if the surface extent of the vessel used in the culture is of any consequence. The practical bearing of these results in the treatment of soils is a matter which may prove of unusual economic interest.

ENGINEERING NOTES.

The underlying principles involved in the treatment of sewage by what is now understood as the "bacterial process" are substantially the same as those which bring about its purification on land, and the recent developments of bacterial methods have directed further attention to many important points in regard to land treatment. The sewage farm effluent is strictly comparable with that derived from bacteria beds, the latter process being in no way "new," but identical with that which obtains in nature—hence, it is in this direction that the solution of the sewage problem should be sought.

The original method of governing gas engines was by what is known as the hit-or-miss method, this being operated by causing the power stroke to be omitted whenever the rotative speed of the shaft exceeded that for which the centrifugal governor was regulated, and resumed as soon as the speed fell below the normal amount. Obviously such a method, although exceedingly economical as regards the consumption of gaseous fuel, did not give a uniformity of speed adapted to the driving of electric generators, and hence in the later machines other systems have been applied.

The question of cleaning the blast-furnace gas which is required for the hot-blast stoves and the boilers in a blast-furnace plant, has not as yet received as much attention in this country as it has in Europe, where most of the large blast-furnace plants have been equipped, during the last two or three years, with extensive gas-washing plants, cleaning practically every particle of gas produced by the furnaces. Very exhaustive tests as to the advantage of cleaning the gas for stoves and boilers have been made by Mr. Emil Hiertz, superintendent of the blast furnaces of the John Cockerill Company, of Seraing, Belgium. As far as the consumption of the hot-blast stoves is concerned he found that by using clean gas the temperature of the stoves could be increased at least 200 deg. F., and it will be seen at a glance that this fact tends to decrease the quantity of gas necessary for obtaining a certain temperature in the hot-blast stoves, so that in the future the percentage of gas to go into the stoves will be materially decreased. Assuming the figure of 30 per cent, the total quantity of gas necessary for heating the blast will be $4,350,000 \times 0.30 = 1,305,000$ cubic feet per hour.

For some time past the British Admiralty have experienced considerable difficulties in connection with the high-velocity weapons mounted on some of the later battleships. The troubles developed for the most part in connection with the 12-inch, 9.2-inch, 7.5-inch, and the 6-inch guns. It was discovered that after a few rounds had been fired the designed caliber of the weapon was seriously obstructed by the accumulation of a copper deposit at certain points in the bore and in such cases further discharging of the weapon was attended with considerable risk. Consequently the guns had to be removed and dispatched to the arsenals for re-boring. This clogging appears to be unavoidable, at least at present, and is evidently inseparable from the existing types of heavy breech-loading weapons. The copper residue is left from the driving band of the projectile and invariably accumulates at one point of the bore. The trouble became so acute, the guns being rendered unfit for service with safety in such a short period, that attempts were made to circumvent the evil or at any rate mitigate its extent, so that the period of disablement might be reduced to as short as possible. The expense of unshipping the guns at the nearest port and dispatching them to the arsenal for re-boring developed into a serious item. Now, however, the engineers at the Woolwich arsenal have succeeded in devising instruments by means of which the defect can be quickly remedied. When the troubles were first ascertained the guns were returned in such numbers and with such frequency that the ordinary working routine of the arsenal was disturbed by the time occupied in reboring the weapons with the existing facilities, and yet at the same time speed was essential in order to prevent the gun reserves being absorbed. With the new apparatus, however, it is possible to remove the deposit with facility and expeditiously, and the instruments have been installed at every naval depot, thereby dispensing with the necessity of sending the defective guns to one establishment, and enabling the re-boring to be undertaken on the spot without any delay. At the same time, however, it would be impossible to have the guns treated at a depot in the case of a battle, and the danger that the principal aggressive armament might be thrown out of action from this cause was so great that experiments were undertaken upon the depot vessels to ascertain whether or not it would be possible to modify the apparatus in such a manner that it could be carried upon each battleship, and manipulated by the artificers aboard. These experiments have proved successful and the scheme is to be adopted. Naval artificers have been instructed in the working of the appliance, so that now in the event of trouble in this direction occurring the defect can be repaired immediately without awaiting the arrival at the nearest naval station. By this arrangement it will be possible to maintain the bore of the guns and appreciably increase the fighting efficiency of the vessel.

THE COLLECTIVE INTELLIGENCE OF BEES.

By G. BONNIER.

WITH the organized anarchy of bees, which was discussed in a previous article, there is associated a collective intelligence which the following examples will serve to illustrate.

In the first place, it should be observed that a worker bee is merely an element of the colony, as a

FIG. 1.—BEES COLLECTING SYRUP WHICH THEY HAVE MADE BY BRINGING WATER TO LUMPS OF DRY SUGAR.

cell is an element of an organized being. An isolated worker is incapable of making a decision, and is less intelligent than a fly.

A fly imprisoned in a bell glass provisioned with syrup and water does not try to escape, but eats and drinks, flies hither and thither, and returns to the banquet, promptly discovering and tasting any new dainty that is added thereto. But if a bee is put under

FIG. 2.—BEES ATTRACTED TO ROSES, WHICH THEY DO NOT ORDINARILY VISIT, BY HONEY PLACED IN THE FLOWERS.

a bell glass with syrup, honey, water, and pollen, substances which constitute a complete diet, and which the bee is in the habit of collecting, it does not pay any attention to them, but incessantly seeks means of escaping and returning to the hive. In this respect no individual differences between bees can be detected. Even if honeycomb taken from the prisoner's hive and impregnated with its special odor is put under the glass, the bee pays no attention to it. The insect has received the order to return to the hive, and it endeavors to obey. It is nothing in itself; it is merely a part of the whole.

If a bee at work on a flower is gently lifted by the wings, it makes no attempt to sting, and when released it returns peaceably to the hive. With an isolated bee

FIG. 3.—BEES GATHERING HONEY-DEW FROM OAK LEAVES.

stinging is a reflex act, to which it must be forced by pinching it between the fingers, as is done in the beesting treatment for rheumatism. When one of the scouts, whose duty it is to seek new harvest fields, makes a discovery, it immediately returns to the hive and, if the scout has been marked, it will be seen, a few minutes later, guiding a troop of harvesters to the new field. In all this the scout has given no proof of individual initiative; it has merely obeyed orders. But when the harvesters have organized regular traffic between the newly-discovered treasure and the hive, the collective intelligence of the society immediately be-

FIG. 4.—BEES GATHERING NECTAR FROM STIPULES OF VETCH NOT YET IN BLOOM.

comes manifest. For example, if roses, which yield little or no nectar, and are not usually visited by bees, are daubed with honey, the scouts at once discover the honey and direct the harvesters to the roses. (Fig. 2.)

The number of harvesters assigned to a task is nicely regulated in accordance with the quantity of matter to be collected, and its distance from the hive. It must not be supposed that the discovery of a bed of sainfoin in bloom will precipitate upon the honey-bearing flowers all the harvesters of the hive. Only the necessary number will come. If the sainfoin is one hundred yards distant from the hive (supposing, for the sake of simplicity, that there is only one hive in the vicinity) a sufficient number of harvesters to gather the nectar will be sent out, but a larger number will be sent to a bed of the same size situated four hundred yards from the hive. This is because the socialistic government of the colony takes account of the distance, and of the time occupied in going and coming, with such nicety that, although the number of harvesters assigned to the task varies with the distance, the number actually at work on the flowers at a given instant remains substantially the same for all distances.

It would be difficult to find a more wonderful example of division of labor than is shown in this distribution of harvesters among various fields. Every day, after the morning excursions of the scouts, the colony is perfectly informed concerning the locations, distances, and comparative values of flowers which contain nectar or ripe pollen, of buds yielding gums, and resins suitable for propolis, and of sources whence water can be obtained easily and without danger of drowning, within a radius which in some cases is as great as two miles.

If the directions taken by the harvesters on leaving

FIG. 5.—BEES FEEDING ON PHACELIA BLOSSOMS.

the hive and the work done on various plants are observed with care, it will be found that the workers are distributed in proportion both to the numbers and the yield of nectar of each species. Some of the workers are also assigned to the collection of "honey dew" from leaves. (Fig. 3.) In Normandy, in early spring, I have seen bees abandon most of the woodland flowers, although these still yielded honey, and attack the nectariferous leaf stipules of vetches not yet in bloom. (Fig. 4.) In the Landes most species of heather are in bloom in August, and at the same season, but only between the hours of nine and eleven in the morning, the oases of the heath are ablaze with the yellow flowers of a species of Helianthemum which open only once, wither after eleven o'clock, and are replaced by others on the following morning. Their nectar is more abundant, of better quality, and easier to collect than that of the heather, and the bees are well aware of these facts, and govern themselves accordingly. Until nine o'clock the heather flowers are covered with bees, but by ten o'clock nearly all the bees have left the heather for the freshly-opened Helianthemum blossoms. Toward eleven o'clock, when the latter begin to fade, the bees reappear on the heather, which soon becomes as populous as it was in the beginning.

Here is another example. The phacelia is an American plant which bee keepers regard as being very rich in nectar and, therefore, cultivate. (Fig. 5.) As a matter of fact, bees visit its flowers when there is nothing better at hand, but the long stamens bother them, and as soon as the false acacia blossoms, the bees desert the phacelia flowers, still rich in honey, for the white racemes of the acacia, in which the nectar is still more abundant and, above all, easier to collect.

When a swarm of bees hangs from a branch (Fig. 6) there is instituted, not a division of labor, but a remarkable system of displacement of tired by fresh workers. It is evident that the bees at the top of the swarm, clinging with their fore-feet to the branch, cannot sustain indefinitely the weight of the whole swarm. If these uppermost bees are marked with red spots, it will be discovered that they are soon replaced

FIG. 6.—A SWARM OF BEES CLINGING TO A BRANCH.

by others. This continuous process of substitution is the cause of the incessant crawling motion of the surface of the swarm.

To those who object that these observations afford no proof of collective intelligence, that this organization of labor is the result of instinct and heredity, I reply by describing an experiment in which the colony is suddenly confronted with an unforeseen circumstance demanding immediate decision.

At night I put some lumps of dry sugar in a spot, partially concealed, at a considerable distance from the hive. In the morning they are discovered by scouts, which inform the colony, and a body of harvesters is sent out. They attempt to seize the dry hard sugar with their jaws, but soon learn that this method of harvesting is not satisfactory, and return to the hive. Soon afterward bees are seen flying from the hive to a source of water, thence to the sugar and, finally, back to the hive.

The problem has been solved by the combined wisdom of the hive, and the harvesters have been ordered to carry water to the sugar and convert it into a syrup, which they can collect in the usual manner, like nectar. (Fig. 1.)

I could fill many pages with examples like these. The study of bees is so fascinating and so fertile in new discoveries, and its apparent monotony veils so rich a variety, that it is difficult to abandon it when one has once begun to penetrate the secret of this perfected civilization, of which the chief characteristic is collective intelligence.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Science au XXme Siècle.

To Remove Spots of Aniline Colors.—This recipe is given for spots which may be found on ceilings, but it would also succeed in other cases. The decoloring action of sulphuric gas is utilized, and for this purpose a quantity of sulphur is burned in the room, after making doors and windows as nearly airtight as possible.—Journal für Praktische Chemie.

THE PHOTOGRAPHY OF PROJECTILES.

THE advantageous properties of the electric spark as a source of light for photography are so well known that it is unnecessary to enumerate them in this place; but what is not so well known are the remarkable results that the spark permits of obtaining for photographing objects having a very rapid motion, such, for example, as the projectiles of fire arms. The minimum time of exposure in cinematographic or instantaneous views scarcely exceeds the limits of 1-2000 of a second, a period which, as short as it is, is altogether too brief to be applicable to the photography of projectiles during their flight. The luminous action of the electric spark should not here exceed 1-100,000,000 of a second, since the projectiles of modern fire arms of small caliber advance during this instant three-fourths of a millimeter. The only method that permits of attaining the end under such circumstances is the one employed by Herr L. Mack at Vienna in 1887, and later at Pola in 1888, for obtaining his fine photographs of projectiles, and which consists in the use of a spark produced by the discharge of a Leyden jar.

In the snap-shot photography of projectiles, not only is an image of the projectile itself obtained, but the aspect and state of the air immediately surrounding it are also registered on the sensitized plate. For this purpose it is indispensable that the arrangement shall combine the following conditions: (1) A proper adaptation of the electric apparatus; (2) an appropriate construction of the optical apparatus; and (3) the exclusion of all foreign light. The room in which the negative is taken must be entirely dark.

The electric spark, of which the light, as we have said, should last but 1-100,000,000 of a second, jumps, at *F*, between two conducting wires. The light produced thereby passes through the condenser *B*, and falls at *S* upon a curved mirror which sends it, through the objective *O*, to the sensitized plate placed in the camera *C* (Fig. 1).

The spark, therefore, very brightly illuminates all the objects that are situated in the cone of light, *S O*. It is evident that it is the ball, the projectile itself, that must incite the spark if we wish that it be reproduced upon the photographic plate. The ball must close the circuit at the precise moment at which it is situated in the cone of illumination of *S O*. In order that this may occur, things are so arranged that the ball shall traverse a plate of paraffine, *A*, covered with tin foil on its two faces, the upper one of which is put jumps at *F* and *A* exactly at the same instant, and the lower one with the conductor *F*. As one of the sheets of tin foil is in communication with the Leyden jar, *L*, and the other with the conductor *F*, the spark jumps at the moment at which the bell connects the two sheets of foil, and its resistance is thus diminished. The insulating layer of paraffine previously offered an opposition to the passage of the discharge. The spark jumps at *F* and *A* exactly at the same instant, and the projectile is therefore photographed while it is in full view in the cone of light *S O*. It should be noted that the Leyden jar and the electric circuit *L*, *A*, *F* are charged by an induction machine *J*.

Other arrangements for photographing by simple spark, derived from the same principle, permit of obtaining a photograph of the projectile alone or with the strata of compressed air that move with it.

It seems surprising that it is possible to fix the image of the motions caused by the projectile in the gaseous element upon the sensitized plate, since such displacements are invisible to the eye. We succeed in doing so nevertheless by taking advantage of a slight difference in the indices of refraction of the more or less dense media; and the two figures that we give herewith furnish an example of it that is instructive in more respects than one.

In conclusion, let us have a few words to say concerning the method of photographing by the electric spark due to Dr. W. Schwinning, who has succeeded in obtaining negatives of the same kind, but in series, or, in other words, has succeeded in taking six consecutive photographs in the space of a thousandth of a second. This method has been applied with a view to studying the effect of balls of small caliber on the human body, and of thus furnishing military surgery with practical information on this important subject.

It is indispensable that the arrangement which serves for the taking of the photograph shall be so established that the images furnished by the successive sparks shall not overlap on the photographic plate. The sensitized surface must therefore itself move very rapidly. Such a result is obtained by fixing the sensitive film upon a steel disk 240 millimeters in diameter placed back of the camera and revolving from 4,000 to 8,000 times a minute, or with a velocity of from 50 to 100 meters a second. In the time that elapses between two successive sparks (1-3,000 of a second), the sensitized surface will thus have traversed a path of sufficient extent to allow each image to fall upon a portion not yet acted upon. The light produced by the spark is of so short a duration that the image is exceedingly sharp despite the motion of the sensitized surface. This method likewise permits of accurately measuring the time that elapses between sparks starting between two photographs.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from the Revue des Sciences Photographiques.

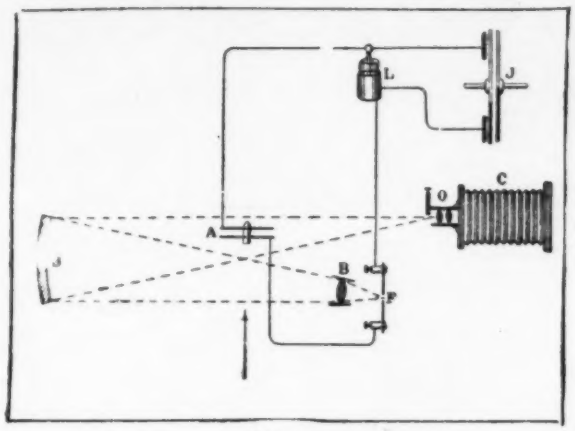


FIG. 1.

OOLONG TEAS AND THEIR MANUFACTURE.

FORMER Consul Anderson, of Amoy, has furnished an interesting report on the manufacture of oolong teas with the object of showing that such teas may be profitably produced in this country. He writes:

It is impossible at this distance to express an opinion of value as to why American experiments in the manufacture of oolong teas have so far been of doubtful success. In the manufacture of tea so much depends upon little things which affect the exact chemical or physical condition of the leaf that even where the leaf itself and the general process itself are the same there may be important differences in results because of very slight variations in conditions. In teas of the hand-cured varieties no opinion but that of experts actually familiar with processes and leaf in both countries concerned can be relied upon safely. It is possible, however, that even a general description of how oolong teas are cured in Formosa may furnish some hints which may be of value in the experiments which are being continued in the United States.

It may be said, in the first place, that Formosan plants used for oolong teas are more rank in their growth as a rule than the Hang-chow teas used in the United States for such teas, but possibly this is due more to the climate of Formosa being much more damp and much warmer than the American fields than to any great difference in the plants themselves. The leaf is handled less expeditiously in Formosa than in the United States. It is picked by women and children, and as picked it is placed in closely woven baskets, which are sometimes lined with jute cloth.

When delivered by the pickers to the curing house, the leaves are spread out in the open air, in the sunshine if possible, on a bamboo mat or in low bamboo trays, and are there stirred every five or seven minutes, until the leaves are somewhat wilted, the edges pliable, and signs of fermentation are visible. The length of time required for this depends upon the sun, temperature, and similar conditions. The tea is then placed in bamboo trays, about 4 pounds in a tray, which are placed in a rack, one above the other, with enough space between to permit free circulation of air and to enable the workmen to manipulate the leaves. The leaves are stirred up in these trays at intervals of from seven to twelve minutes, as required, the fermentation being regulated and kept as even as possible in this manner. Fermentation ordinarily is allowed to proceed for about two hours, after which a rack of tea, about 40 pounds of the leaf as a rule, is turned into a large circular bamboo tray and is again stirred and manipulated for two hours more, at the end of which time the edges of the leaf are somewhat dry, reddish brown in color, and with considerable of the odor of prepared tea.

The leaf is then taken in lots of 4 or 5 pounds and placed in metal firing pans over charcoal fires hot enough to wilt and curl the leaf, giving it the soft, sponge-like quality of damp tea leaves and enabling it to be rolled, this firing or wilting being accompanied by rapid stirring and tossing the leaf in each pan. The lot of tea is then turned into a round-bottomed pan fixed in the end of a bench, upon which a workman sits, and the leaf is then rolled by hand to give it something of the form of ordinary country-cured Chinese or Japanese teas. The tea is given a second pan drying, followed by another rolling, and sometimes even by a third drying and rolling, although generally two rollings suffice. This rolling is followed by a drying sufficient to get the leaf in such shape that it can be transported to the export firer. This alternate process of drying and rolling varies with the weather, and indeed the whole process depends upon the conditions surrounding the leaf. The process takes the green leaf, oxidizes or ferments it until the edges turn a reddish brown and the entire leaf is wilted; then wilts the leaf over a fire until it can be rolled to give it form, later drying it for temporary packing. This latter process often includes a light firing in a basket over a charcoal fire.

The tea thus prepared for temporary keeping is known as "green leaf." It is packed in jute bags holding about half a picul, or about 66 pounds, and is transported to the export firer. The leaf thus packed is dry, but it lacks the brittle condition of the tea as it is received abroad, and generally is much lighter in color than oolong as known to the trade. When received at the firing house it is picked over by women and girls for the removal of stems, dirt, or foreign matter generally. The final firing for export is done in bamboo baskets, giving the name of "basket fired" to the product. The firing which produces characteristic oolong is generally done in a medium-sized room in some of the great brick buildings housing the great tea establishments. In a firing room a brick platform about 20 inches high is constructed, in which are round holes about 2 feet deep and 2 feet in diameter, ordinarily about a foot apart, and numbering from 50 to 300 or even 400 in an establishment. In each one of these holes a charcoal fire is built and the charcoal is burned until all flame disappears, the room becoming a great furnace into which the coolies rush with covered mouths and nostrils to stir the fires and prepare the little furnaces. When finally the charcoal in each hole or furnace becomes a bed of live coals without flame, it is covered with charcoal ashes to temper the heat and preserve the fire. The entire room is still hot and is maintained in that condition for days at a time. Ordinarily it will require perhaps twelve hours to burn the charcoal to a proper condition and have the room at a proper temperature, the covered charcoal giving off a steady heat.

The firing is done in bamboo baskets about 3 feet high and a little over 2 feet in diameter, open at both ends, and with a sieve placed a little below the center as a bottom. Such a basket is placed over an open furnace or hole in the brick platform, and about 7 pounds of the green leaf are placed in it. The leaf is practically untouched for about three hours, until the quantity of leaf in the basket has become thoroughly and evenly heated, naturally running through a slight wilting in becoming heated. Firers then pass from basket to basket stirring the leaf, so as to keep the

FIG. 2.—FURROW AND HEAD OF WAVE OF AN 88 BALL.

FIG. 3.—FURROW AND HEAD OF A PRUSSIAN INFANTRY BALL OF THE MODEL 82V = 640 METERS A SECOND. REDUCED TO 0.45 OF THE ACTUAL SIZE.

drying process even and regular, ordinarily about an hour between the stirrings being sufficient. It generally requires from seven to twelve hours of such firing to thoroughly evaporate all moisture in the leaf, baskets generally being set in the evening and removed in the morning, the tea being boxed while warm. The firing of the tea also varies for the variety of tea desired, heavily fired teas being desirable for some markets because of the darker infusion they give.

Machine curing of tea has been attempted in Formosa, and the Japanese government is now supporting an experimental machine plant at Anping, Formosa. It is generally agreed by tea men, however, that the results so far have not been successful or satisfactory from any standpoint and that the plant is run at a loss. There is no present likelihood of the machine method succeeding that of hand firing. The fact is that while, of course, oolong tea derives more or less of its meritorious qualities from the nature of the leaf itself, there is peculiar merit in the manner in which the leaf is handled and much depends upon little things which a machine can not accomplish. From this fact it may be perceived readily that any description of the process of curing these teas will necessarily be incomplete and more or less unreliable, which does not represent the actual experience and work of experts, in this case Chinese workmen.

Since conditions of climate, as well as of the leaf to be cured, vary greatly, it is impossible to pass upon the matter of oxidation or fermentation satisfactorily by ascribing a certain time to a certain process, when, as a matter of actual practice, it may require much more or much less time to effect such process under different conditions. Either expert workmen from China or Formosa should be employed in the United States, or American tea men should have a practical training in the processes of making teas in China or Japan, or at least should make a personal investigation of such processes. I certainly see no reason why oolong teas should not be grown and properly cured in the United States with success, since other varieties of tea are being successfully produced.

ELECTRICAL NOTES.

Kryptol.—This substance, manufactured by the Berlin Kryptol Company, is a black granulated mass composed of charcoal, carborundum, clay, and silicate, the exact composition of which is not made known. For feeble currents of high tension and for obtaining low degrees of temperature, a mixture of charcoal and silicates is employed, as stated by the company. The higher the tension the smaller the grain of the mixture, and then conducting substances of the second class must predominate. This company constructs a great variety of apparatus for heating, in which kryptol is utilized as a resisting agent.

Electricity in Japan.—Electrical industry has been rapidly developed in Japan, due in great part to the Nippon Denki Kiowai, association of Japanese electricians, founded in 1892 for facilitating the progress of electric lighting, for acting as the representative of the industry in treating with the public authorities, for publishing reports instructive to the people, and for maintaining a permanent electrical exposition at Tokio. The executive committee meets every month, and the association has a general meeting annually. The exposition is open daily. The exhibitors bear the expense of electric lighting and the running of machines. The association has recently published a history of the Japanese industry from 1888, the year of its introduction. At the end of the first decade, in 1898, the production of the current had risen to 11,000 kilowatts, and five years later, in 1903, to 26,000 kilowatts. The war has tripled the purchase of machines, which are mostly imported from the United States.

Electrical Traction in Mines.—The Bulletin Semestriel de la Société de l'Industrie Minérale publishes a description of the plant and arrangements for the electric conveyance of coal extracted from one of the divisions of the mines of the Loire, and of gobbing and other material, between Rambaud and Loire, a distance of 1,400 yards, the screening and washing shops being near the latter place—a description furnished by M. Morchoine, engineer of the mines. For supplying the current a Bietrix steam engine is employed, actuating electric mechanism by which over 25 cubic yards of water can be pumped from the shaft per hour, a height of 370 yards. This operation takes place in the night, and the generator is otherwise disposable during the day. Of the total track, 400 yards are in the open and 900 underground. The track is single, with garage in the center of the course. The conductor of the current is of copper, supported by posts in the outside portion, and below ground attached to the roof of the drifts. The return of the current is by the track, the rails being connected with the negative pole. The locomotives weigh 8,000 pounds, their total length is about 10 feet, and their height nearly 4 feet. They can draw trains of 25 loads of gob-stuff, weighing 25 to 27 tons, at a maintained speed of 20 miles per hour. This mode of traction has reduced the cost from 0.222 franc (1 franc = 20 cents) by animal traction to 0.131 franc per ton, a saving of 1,200 francs per month, a sum sufficient to pay for the plant in less than four years. Besides, without increase of personnel, a larger number of loads can be drawn within a given time, so that altogether M. Morchoine estimates the cost at 10 centimes per kilometric ton. If, for any reason, there is delay in the work at the mines, the employment of electric motors allows, in large measure, for making up the time lost.

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